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The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

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The Next Session of the Foundry School

The Governors of the British Foundry School have issued a statement stressing the necessity for the industry giving some indication of the number of students likely to present themselves for next session. A large number of students each year was never expected or, indeed, desired. For the first session, in the year 1935-36, the number was thirteen, higher than was expected. For the current year, 1936-37, the number fell, probably on account, at any rate in part, of the exceptional business pressure on foundries which prevents them releasing men. Since the object of the school is to offer intensive training to those who have already entered the industry and obtained some practical experience and technical knowledge, its entries are confined to men from the industry, who will return to it. Thus the school is completely dependent on the industry for its supply of men, and the usual plan is for a firm to send one or more of its promising men under an agreement to return to the firm for a period of years; in this way the exceptional facilities afforded are recognised. These facilities include a foundry visit each week, and something like 120 lectures from nationally known specialists during the course, apart, of course, from the work of the permanent staff. Those who wish to take the course on their own initiative are also welcomed, and where the cost of doing so is a handicap, it is believed that the Education Committee in the area concerned would in many cases be prepared to assist. Eminent authorities act as assessors in the diploma examination, and the diploma itself is endorsed by the Board of Education. There is no age limit for admission, and this averages about 25. All those who have any sort of official connection with the industry are constantly faced with requests for men for responsible positions, men who are at present not available and who show no sign of becoming available unless through a training organisation. It is for the purpose of providing this training that the British Foundry School was started, just as various schools were stated many years ago on the Continent. One such school for training foremen can look back on fifty years' history. The School therefore appeals to prospective students and their employers to make their intentions known as early as possible for the session beginning in September next.

A Problem in Nomenclature

Mr. G. T. Lunt, in our annual review number, encountered a difficulty which is rapidly becoming a general one. This difficulty was to find a suitable name for a class of machines which clean the surface of castings, forgings and other metallic entities through the impingement of a stream of chilled iron grit or shot ejected by centrifugal force at high speed from a rotating container. These machines are widely known by their trade names, and the proprietors of one, the name of which is particularly appropriate, may not welcome our effort to find a name which will embrace the complete series, yet when this firm's engineers address scientific societies, they, too, would no doubt feel happier if they could utilise a term acceptable to the whole industry in the same way that one speaks of "core blowers." There are several types of core blowers, and the term has met with universal approbation.

The search for a suitable name for this type of cleaner, however, takes one into a maze of difficulties. To incorporate the word "airless" in the term is slightly unsatisfactory, as is the notice on the Underground Railway, "Not stopping at Covent Garden"—it is somewhat negative. A pitfall also encountered is the introduction of the word "centrifugal," as there is a liability of this description being applicable to tumbling barrels. There is one common feature about the machines under consideration, and that is that a stream of metallic abrasive is ejected from the periphery of the container for the purpose of cleaning metallic surfaces. We have passed in mental review such names as centrijectors, perijectors and a host of other coined words, but we think that the phrase coined should have a foundry flavour. The Sandslinger as a machine enjoys a monopoly of type, and no difficulty has ever cropped up as to its use in literature, and if there be no adverse commercial considerations, we suggest the new type of machines should be known as shot-slingers.

American Notes

Die casting enamels for finishing non-ferrous alloy die castings have recently been placed on the market in America. They are air-drying lacquer type enamels that produce a durable elastic finish in one coat.

* * *

The Alleghaney Steel Company has started the installation of an additional 25-ton electric furnace at Brackenridge, Pa. The new furnace will be used for high grade special steel alloys and is expected to have 3,000 tons a month capacity.

* * *

The latest development in the scrap steel export trouble is the resignation of Mr. Darwin S. Luntz, of Canton, Ohio, President of the Institute of Scrap Iron and steel, and two governors of the Institute. The resignations were brought about by the introduction of a resolution at a board meeting in which the Institute opposed all legislation interfering with free and open markets. Mr. Luntz stated that a difference of opinion on a vital matter of policy prompted his resignation, and that it should not be construed as a split in the ranks of the scrap iron dealers.

* * *

Mr. Michael V. Bonomo, former Vice-President, has been nominated as President of the Institute. In a public statement Mr. Bonomo said that exports of scrap iron and steel kept the industry from bankruptcy during the depression and that no defence was needed for the logical and natural export of scrap. On the other hand, the Independent Steel and Iron Producers remain firm in their efforts to obtain legislation to licence exports of scrap. According to a bulletin, they are "firmly convinced that the situation can only be handled in this manner. Even the thorough co-operation of scrap dealers themselves would be no guarantee of controlling this export of our natural resources. Only legislation can control it."

* * *

Prof. Colin G. Fink, of Columbia University, explained an electrolytic process for recovering manganese from its ore at a recent general meeting of the American Electrochemical Society. American steel manufacturers hope that the method can be applied for the utilisation of large deposits of low-grade manganese ore in America. There are extensive deposits of low-grade ores in Alabama, Nevada, and in other sections. Boulder Dam promises cheap electrical power; therefore it would be possible to get manganese in quantities from American ore at reasonable cost. Prof. Fink produced samples of manganese deposited on copper. He pointed out that the electrodeposited manganese was hard and resistant to scratching and abrasion, and it was probably due to lattice distortion caused by the simultaneous deposition of hydrogen.

Catalogue Received

Oversize Particle Elimination in Grinding. A four-page leaflet, sent to us by International Combustion, Limited, of Aldwych House, Aldwych, London, W.C.2, treats of the Raymond vacuum separating plant. This machine is so designed that it will deliver a constant uniform product, free from coarse oversize of any fineness to 550 mesh and finer. We believe it might be useful for those interested in vitreous enamelling to learn that when dry grinding clay, a 3-ft. vacuum separating plant is handling a feed of 12 cwts. per hour to a fineness of 99 per cent. minus 40 mesh B.S.I. This is the smallest standard size, others of the range being 4 ft. 6 in., 6 ft. and 7 ft. diameter.

Symposium on Radiography and X-Ray Diffraction Methods

The Symposium on Radiography and X-ray Diffraction Methods, which has been developed by a committee of the American Society for Testing Materials, presided over by Dr. R. F. Mehl, with the close co-operation of Dr. H. H. Lester, Dr. John T. Norton and Dr. C. S. Barrett, has been prepared by outstanding authorities in the field. Six of the twelve Papers which it contains deal with radiography, covering principles, foundry applications, radiography in the welding shop, miscellaneous applications of radiography and fluoroscopy, radiographic specifications, and gamma-ray radiography and its relation to X-ray radiography. An appendix to this last Paper provides instructions for radiography with radium. The authors of the Papers in this section include: Mr. John T. Norton, Mr. Earnshaw Cook, Mr. J. C. Hodge, Mr. Herman E. Seeman, Mr. H. H. Lester and Mr. Norman L. Mochel.

The six Papers devoted to diffraction cover equipment and methods, constitution of alloys, chemical analysis, determination of particle size, applications to non-metallic materials, and to problems of cold work, preferred orientations, and recrystallisation. The authors in this section include: Mr. Charles S. Barrett, Mr. Kent R. Van Horn, Mr. Wheeler P. Davey, Mr. John T. Norton, Mr. G. Harvey Cameron, and Mr. George L. Clark.

The final symposium held in four sessions of the 1936 A.S.T.M. annual meeting was preceded by a preliminary symposium at which many workers presented results of their work with special emphasis on case histories of successful applications. All of this material was available to the authors of the final Papers.

The publication is profusely illustrated by 145 halftones and 50 line drawings, adding to the utility of the publication, which covers 350 pages. Copies in cloth binding can be obtained from A.S.T.M. Headquarters, 260, South Broad Street, Philadelphia, price $4 each.

(Concluded from next column.)

beware. South African wines are very strong. There is nearly three times as much proof spirit in a shilling's worth of South African Red Wine as in a shilling's worth of Whisky. Of course, any Scotsmen who wish to get an extra kick out of life for the same money will know where to find it!

* * *

Mr. Funk, an American dictionary expert, has been busy deciding which are the ten most overworked words in the American language. It would be difficult to confine one's choice to ten in England, where every trade and different social plane has its fashionable word. Even Mr. Funk's very name has had its day amongst our school boys and girls. It offers possibilities for quite a "wizard" game, however, running round noting down the popular phrase in the different circles in which one moves. Nevertheless, it would take a brave man to set down in cold print the most popular word (or string of words) prevalent in some of our steel foundries.

* * *

Saying of the week. Herr Hitler: "The individual has only one choice. He must bend or break."

He cannot have heard of elastic stress.

* * *

Seen in the Coronation decorations: A banner across the streets in North London inscribed with the words, "Lousy but Loyal."

* * *

Heard amongst the Coronation crowds: "Daddy, whilst we are in London, will you take me to see the Roman Catholic Bath in the Strand?"

"MARKSMAN."

Random Shots

How many people who travel by train a great deal in the course of their business pass the weary hours re-wording the advertisements to be seen everywhere? There is a certain series of advertisements, now very familiar, which lends itself particularly well to this fascinating game. Why should "Muttex," for instance, only be popularised amongst railway travellers? Why not amongst foundry workers? You, too, need "Muttex," for "Muttex" protects you against that cold-blast. "Muttex" is the best heat treatment. "Muttex" will make you into good runners and risers. Its possibilities are legion.

* * *

It seems that workers with metals cannot get out of the habit, however old they become. An old man in Yorkshire, now 91 years of age, is still busy making chains for farm implements, working in a small shed in the back garden of his cottage. South Kensington Museum is preserving a set of his old chain-making tools.

Occasionally one hears of other workers in metals putting their skill to baser uses, but when their tools are found they are preserved in the Scotland Yard museum and the experts preserved in gaol!

* * *

"Marksman" has received from Mr. Fassotte this very interesting proof of the identity of the mysterious black lady. The lady in question, Tibie by name, has evidently been following the

story closely. Could it be that she was watching her master's interests in the matter of a possible libel action or was she just enjoying the joke?

* * *

A meteorite found in Australia and presented to the British Museum in 1861 was placed on a pedestal for show purposes. It began to rust so quickly that it had to be put in a glass case and nitrogen pumped in. Surely the poor thing cannot be blamed for displaying the same tendencies as a good many human beings the moment they are placed on a pedestal, and surrounded by gas.

* * *

"Thank you so much," said a woman to a man who had given her his seat in a street car. "That was very kind of you."

"Not at all, ma'am, not at all," protested the man. "I know some men don't give up their seats to anyone except pretty girls, but looks don't make any difference to me."

* * *

It has often been wondered what beverage it is that makes attenders at big dinners, participators of Congresses, devotees of Buffalo meetings and the like, so merry and bright towards the early hours of the morning. Is it beer? is it whisky? or is it "Red Biddy"? The slogan "Buy British" is firmly rooted in the average Britisher's mind, and "Red Biddy" is a mixture of British wine and methylated spirit pinched from the works lab. And it is very potent! If there is ever an Empire Foundry Conference in South Africa, now that they have a Branch of their own, English visitors must

(Concluded in previous column.)

A New Era in Foundry Lighting

THE SAFETY ASPECT

The problem of foundry illumination has found recently a solution which bids fair to bring about something like a revolution, with benefit to all concerned. In the past the economic difficulties of obtaining good lighting were well nigh insuperable. Extensive bays devoted to the rather slow production of bulky products of comparatively low intrinsic value would not, in the nature of things, bear a big outlay on lighting either for installation or maintenance. The practical compromise usually arrived at provided illumination far below the standard desirable for rapid easy work and maximum safety for the operatives.

The coming of the mercury electric discharge lamp however, has changed all that. This new illuminant, working from any 200 to 250 volts a.c. supply with no more complication than the interposition of suitable current-limiting choke coils in series with the lamps, has brought a new era in foundry lighting. In its present stage of development the mercury discharge lamp provides up to 45 lumens per watt or close on three times the light of the best gas-filled tungsten-filament bulb consuming equal energy. Thus for the first time it is possible to provide a satisfactory amount of light without unduly burdensome overheads.

But though " more light for the same expenditure " may be the salient feature of Osira and similar mercury lamps, since increased light means first and foremost greater safety and increased production, there is another not so well known feature of the new equipment which deserves special and particular mention.

Artificial light derived from heating solid matter varies in accordance with the physical law that the colour of the light rays depends on the temperature of the radiant substance. To put it very briefly, the higher the temperature the whiter the light. An oil lamp, an open gas jet, or a carbon filament electric bulb all give in proportion to the energy used, a very dim light with a marked preponderance of red rays. The incandescent gas mantle and the gas-filled filament electric lamp, working at far higher temperatures, give a much better balance between red and blue rays, and the light is a closer, but by no means perfect, counterfeit of daylight. The mercury discharge lamp however, employs a totally different system of evolving light, and its radiance is of a quality peculiar to itself.

The Osira lamp produces light by the passage of an electric discharge through mercury vapour and several rare gases. In the process, the molecules of vapour are put into a state of intense agitation and emit radiations in the form of visible light. But—and here is the important point—the light is confined almost entirely to yellow-green-blue rays with an almost complete absence of red.

The result is a clear silvery light which gives unusual clarity of vision where definition is required, but where colour discrimination is of less importance—precisely the conditions which prevail in the average foundry. Even without an increase in lighting intensity, objects show up with greater sharpness, and in addition slopes, steps and spaces show up far more readily.

THE FOUNDRY OF FRASER & CHALMERS, LIMITED, LIT BY OSIRA LAMPS.

Shadowed areas seem more luminous and the blackness of the roof spaces becomes much less oppressive.

Furthermore, the light from mercury discharge lamps has a specially " penetrating " quality, not only getting through a smoky or steamy atmosphere, but also (due probably to its being reflected more efficiently from the walls of the average foundry building) enabling the interior of sand moulds and hollow castings to be examined by the ordinary overhead shop lighting. This point, besides its practical convenience, makes an important contribution to safety, since there are obvious objections to using portable inspection lights on the damp floor of a foundry, as well as the risk of the operator damaging moulds and cores when probing their interiors with his lamp.

Osira lighting, although new to the metal founding industry, is by no means untested. Such firms as Stanton Ironworks, the Lancashire Steel Corporation, Shanks & Company, Ransomes, Sims & Jefferies, the Met-Cammell Wagon Company, and Fraser & Chalmers, all have large numbers of the lamps in use with satisfaction not only to the management, but to the workmen concerned.

OSIRA LIGHTING INSTALLED AT THE FOUNDRY OF LEY'S MALLEABLE CASTINGS COMPANY, LIMITED.

Chromium-Carbide Coatings

In United States Patent 2,048,276, B. S. TESCHNER describes a process for coating iron and steel with chromium carbide in order to enhance their surface resistance, such coatings being claimed to be hard, heat-resistant, and chemically unattacked. The surface is first coated with chromium by electrolytic means, after which all occluded gases are expelled by heating at 300 deg. *in vacuo* for 30 min., and finally carburising the coating. Carburisation is affected in an atmosphere or current of hydrocarbons, the surface being heated to 800 deg. Tungsten-carbide coatings can be prepared in the same way.

Iron and Steel Green Sand Castings

After the Paper "The Manufacture of Iron and Steel Castings in Green Sand,"* by Dr. C. J. Dadswell, Mr. T. R. Walker and Mr. F. Whitehouse, had been read before the Sheffield Branch of the Institute of British Foundrymen, an interesting discussion was held.

Limitations of Green Sand

Mr. J. Roxburgh (Branch-President) said there were definite limitations to the number and the nature of castings that could be made in green sand. In the foundry with which he was concerned, where high-class engineering castings were made, it was found that, except with small castings and repetition castings, they could not use green sand to any great extent. They did use green sand in some cases, but with high-class engineering castings it was essential to melt the metal at as high a temperature as possible, and in the majority of cases to cast as hot as possible. With the majority of their castings it was found necessary to make them in dry sand. In the iron foundry they had to have a particularly skilled man to ram a job up in green sand as the question of ramming in the iron foundry was particularly important. He wondered if the density of ramming and the variation of ramming from one particular job to another were as important in the steel foundry as in the iron foundry. The task of finding skilled moulders used to green sand was a very difficult one, and during the past few years many ironfounders had changed over to dry sand for the better class of work, whereas, in steel foundries, they seemed to be reverting in many cases to green sand. Mr. Whitehouse had remarked that his foundry was a jobbing foundry, but the illustrations of the boxes and fabricated core irons he used, and the wide application of his green-sand cores, indicated that what was being done was definitely on a repetition basis. This had to be considered in relation to the suitability of green sand for a particular job. If Mr. Whitehouse was in a jobbing foundry and had to make one-off it might have been a very different matter. He also knew that the fabricated irons were made use of in mechanised plants. He presumed that as Mr. Walker's mixture was a synthetic sand he was able to add a definite amount of water, but a similar position did not arise in iron foundries where they had to accept the sand sent to them, whether it contained a large or small percentage of water. He had understood from the Paper that sands used in the steel foundry were under complete scientific control.

Central or Individual Sand Control?

Mr. J. B. Allan agreed with Mr. Roxburgh that it did not seem to be completely jobbing work which the authors had described because of the amount of special tackle, such as shell patterns, special core irons, and fabricated core irons which were used. He had wondered how this was done where there was apparently no sand control by mechanical means, the control, therefore, being completely dependent on the skill of the individual moulder. However, Mr. Whitehouse concluded by saying that it did depend on the skill of the individual moulders. In the iron foundry with which he was connected they had to exercise the most rigid sand control to enable them to make their castings with unskilled labour. With proper sand control they could obtain quite remarkable results both in steel and iron.

Mr. F. Whitehouse, in reply, said that the question of what constituted a jobbing shop was rather difficult. They found that 12-off or even 10-off warranted a fabricated core iron on certain jobs, because they lent themselves to such cheap production. The question of the quality of the castings was also very difficult to assess, because definite standards were rather elusive, and finally the customer had to decide. He manufactured the castings in the manner described because at the present time it was the cheapest way he could find, and the castings had satisfied the customer. As soon as sand control was introduced, they began spending money, and they might spend more money than they saved. If they wanted to make sure of a job, they did not turn at once to stricter sand control; they simply dried the mould.

Unexplored Aspects of Sand Testing

Mr. E. Wharton said the points which Dr. Dadswell and Mr. Walker had made in regard to technical control were extremely important, and in supporting Mr. Allan's remarks he agreed that skilled men were becoming more scarce in the industry. Mr. Whitehouse was fortunate to be in a works where the men were artists at their particular jobs. Everyone was not so fortunate, however, and, where skilled men were not available, it was necessary that technical control should be exercised. There were still a few interesting aspects of sand testing that required to be more fully explored. One of these was the question of the plasticity of bonding clays, and they also required a method of measuring the "toughness" of the sand which was not shown by a green sand compression test. Many people who were interested in sand control would be glad to know of some method for measuring such properties, and if Mr Walker could indicate how he made such a determination, it would be of great service to members.

Rapid Tests Essential

Mr. T. R. Walker said, with regard to Mr. Wharton's last point, that batches of sand must be tested before they were sent on to the foundry floor. In this testing no method was suitable which could not be carried out in a few minutes, as it was not desirable to hold up the batches of sand for the foundry. This meant that any determinations of strength could only be those of green compression strength. It was unfortunately true that they did not yet know the nature of all the properties of sand which governed its successful employment in the foundry. There was still a great deal of fundamental research which must be done before that state was reached, and even when it had been done, it was very doubtful whether the fundamental properties could be tested in the foundry by quick methods.

Consignments of sand were tested before being made up into mixtures for use in the foundry. In this case, if they started with materials which from previous experiments they knew would give successful results, then they only had to see that different consignments had the same properties. For the investigation of fresh raw materials he was afraid that at the moment all they could do to choose between different raw materials was to adopt some form of shop test. For example, they could make slab moulds, either green or dry, of a fixed size and fixed section, fill them with liquid steel and examine afterwards the surface of the castings obtained.

A great deal had been said during the discussion about the control of sand. He thought that Mr. Whitehouse was not working without the control of his sand, but was having it controlled in fifty different places by fifty different men, each man controlling it so that it gave satisfactory results when used in his individual way. In a repetition steel foundry technical control of sand was necessary since every moulder was expected to treat the sand in the same way. It did not matter in the least whether the testing was done by a boy with a permeability apparatus or by some of the experienced moulders who relied on the feel of the sand. The judgment of a man who had had sufficient experience could be relied upon, but if he fell ill and there was no other person with similar experience the foundry would probably suffer, whereas boys could be trained in a very short time to give very similar results when using the apparatus to which he had referred.

Regarding the fact mentioned by Mr. Whitehouse that much of his sand on the floor was not milled, it was a fact that by treading sand or kneading it and rubbing it together they could get better mixtures and quite as good uniformity as in most types of modern mill.

Mr. M. Brown said stress had been laid on the limitations of green sand moulding, but he wondered whether the limitations applied so much to the green sand as it did to the manipulators of the sand and their lack of experience. An iron foundry which he knew did a considerable amount of machine-tool work, which called for a very high degree of finish, and although he would not like to say definitely what their limit was, he had seen 6- or 7-ton castings in green sand. He was specially interested in the dredger bucket that Dr. Dadswell showed, and he asked for some indication of the weight of the bucket, whether all the cores were in green sand, and if any chills were put in for any special crossings. In regard to Mr. Walker's 100-day test, he noted that they started off with naturally-bonded sand and experienced much trouble, but by using silica sand much improved results were secured. Would Mr. Walker tell them whether, when he started on his naturally-bonded sand, he began his experiment with sand that had been in the foundry for a considerable time? This would mean that when the first sand went through the re-conditioning plant he would remove a different percentage of moisture each time, probably until his sand reached a constant condition. This would help him when he started on the silica sand.

Synthetic Sands

Dr. C. J. Dadswell said that for some time they had been experimenting with synthetic sand. Whilst he was on the Continent he saw the good results that were being obtained in green sand, and he also knew that in the United States similar work was being done to that which was done at the foundry with which he was associated. He knew the foreign founders were using synthetic green sands and he was determined that his firm should try similar sands. When changing over from one sand to another they did not take away all the sand but gradually made additions of the new type of sand. Generous additions of the new type of facing sand were made until it was found that there was an excess of backing sand and after this so much of this sand was thrown away every week. As a matter of interest he tried to work out mathematically how long it would be necessary to carry on with the large additions of new sand before the complete nature of the backing sand was changed. Eventually they came to a point when they could reduce the amount of facing sand added. The bucket to which Mr. Brown had referred had a dry sand core. They had to try several runners before they could find one that was satisfactory, both from the point of view of washing the mould face and cracking troubles. Finally satisfactory results were attained and the buckets were made without cracks, whereas in dry sand cracking always occurred. The weight of the bucket was about 14 cwt.

Density of Ramming

The question of the density of ramming in the steel foundry, mentioned by Mr. Roxburgh, was of considerable importance. In fact, the best results in green sand were obtained by machine ramming because uniformity was obtained. Belgian sands, of course, were suitable for green sand work but at the same time it had to be remembered that on the Continent their cost

* Foundry Trade Journal, April 22, 1937.

was much less than it was in this country. In the United States many developments were made in the use of synthetic sands. At one time they used large quantities of Belgian sands, but during the war it became difficult to get them and they developed synthetic sands. Mr. Roxburgh had mentioned the question of the sand arriving wet in wagons. That problem had to be overcome by drying the sand if the percentage of new sand used was sufficient to make it impossible to get the final sand mixture of the requisite moisture content.

MR. J. H. PEARCE said he gathered that from the point of view of solubility a steel could be satisfactory in dry sand and not in green sand. Perhaps Mr. Walker could tell them a little more about this, and as he had his sand under control, it seemed to him essential to have the steel under control as well. Perhaps Dr. Dadswell, who had mentioned that green sand moulds could only stand with safety a certain length of time before casting, because of the moisture collecting, could give him an idea as to how long a mould could reasonably be expected to stand in green sand.

"Irritant Centres" in Green Sand Moulds

MR. T. R. WALKER said that steel for any foundry purposes should be fluid and should have a low gas content. This applied equally well whether the moulds were green or dried. The important point about green sand was that it evolved a great deal of steam, some of which passed through the steel and very often disturbed the gas already in the steel. It could be compared with heating some water in a perfectly clean flask. This water would reach the boiling point and would not boil until heated to a higher temperature, when there would be a sudden evolution of steam. If, on the other hand, a piece of pipe clay was put in the flask with the water, any sharp corners on the fracture of the pipe clay would promote the formation of bubbles, and there would be a steady evolution of steam at the boiling point. In the same way they often had what was called in the foundry irritation in a green sand mould, and the evolution of steam, combined with the effect of small points in the mould acting as irritant centres, which tended to evolve gases in the steel which would not otherwise be evolved.

Vote of Thanks

MR. H. WINTERTON (President of the Institute), proposing a vote of thanks to the authors of the Paper, said he had enjoyed both the reading of the Paper and the discussion. He contended that the old practical moulder of many years ago was really a technician, and had gained his knowledge through practical application and by carrying out his work correctly time after time through years of practice. He could not tell them why he obtained certain results; he could not supply technical names, but year after year he carried out the work accurately. The man who might be described as working by rule of thumb was really a technician, and he felt they wanted more of such men. Now that there were additional educational facilities, they ought to insist on the younger men taking the lessons that were now so freely given and which in the old days were never at the disposal of the moulder.

The vote of thanks was seconded by MR. A. WHITELEY and carried.

International Nickel Company

A net profit of $11,714,957, equivalent to 77 cents a share on the common stock after allowing for preferred dividend, is reported for the first quarter of 1937 in the quarterly statement of the International Nickel Company of Canada, Limited. This compares with a net profit of $9,836,446 for the last quarter of 1936, which was equal to 64 cents a share on the common stock. It compares also with a net profit of $8,386,787, or 54 cents a share, made in the first quarter of 1936.

Cement as a Binder for Moulding Sands

MR. CARL A. MENZEL, of the Research Laboratory, Portland Cement Association, Chicago, Illinois, in a Paper read before the Milwaukee Meeting of the American Foundrymen's Association, states that the use of Portland cement as a binder in foundry moulding and core sand is not new. Cement has been used to a limited extent in this field for some forty years and such use is mentioned in a book by Richard Moldenke on "The Principles of Iron Founding," published in 1917.

Although Portland cement is one of the most highly developed and widely used media for binding particles of sand and stone together in concrete it has not been extensively used in foundry practice. Recently, however, there has developed a marked interest in the possibilities of cement for foundry use, which may be due to the combined effect of several factors. One of these is the intensive effort of foundry technicians to improve the quality and reduce the cost of castings. Another is the development and general availability of inexpensive cements of high initial strength. A third factor which has stimulated interest are the reports of the excellent results obtained with cement binder in a process used in a few European and American foundries.

General Considerations and Scope of Tests

There are several points which bear on the general success or failure of almost any binder in foundry sand moulds. Briefly, it is desirable that after ramming, the mould should have high green strength so that it can be handled without damage until the time the steel is poured a few days later. The surface of the mould should be hard and the mould should be strong, but not too strong, as it is desirable that it yields somewhat under pressure of the steel as it solidifies. The mould should contain as little moisture as possible, particularly at the surface, in order to avoid the sudden formation of steam. It must also be permeable to the escape of gases but the surface must at the same time be clean, smooth, and hard, so as to provide a smooth surface on the casting. It is very important that the mould surface be free from materials which will lower the fusion point between the steel and the silica sand. Lime is particularly objectionable on the surface of the mould for this reason.

On the basis of these general requirements, it appeared desirable to divide these studies of cement binder into two parts. The first part includes a study of those factors which normally could be expected to influence the strength and permeability of a partially hardened cement-sand-water mixture at the age of about three days. The second part involves the development of a surface wash or other preparation with which the surface of the mould can be treated to prevent or reduce the burning-on or fusion of the steel with the silica sand at 1,593 deg. C.

This Paper reports the results available thus far from the first series of laboratory studies. These have provided information of general interest regarding the influence of such factors as type of cement and cement content, moisture content, type of sand, ramming, etc., and have established which factors are important and which are of less consequence.

It was apparent from the beginning that to maintain proper control and to secure uniform results with cement binder the face of the mould would have to be made from a carefully proportioned mixture of cement, and suitably-graded, fresh, clean sand, and water. It seemed also that such a high-grade facing layer approximately one inch thick could be backed up with any suitable combination of lower grade materials. The studies were carried out assuming such a combination would be necessary in practice. For instance, under one plan of operation all of the material available from a mould made of both high-grade cement-bound facing and a lower grade of cement-bound backing may be crushed and returned to individual sand grains to make the mixture to be used for back-up in the next moulding. This mixture will contain some hydrated or spent cement. When it becomes loaded with too large a quantity of spent cement with repeated additions of new cement, the excess fines can be easily blown out. Under another plan the entire cement-bound mould may be crushed to form particles of varying size up to $\frac{3}{8}$ in. or more to which new cement is added to form backing material simulating very lean concrete. Under a third plan the back-up may consist of light-weight aggregates such as slag, cinders, or burned shale (Haydite) held together by cement.

Whatever methods or materials be employed for backing up the facing, it should be emphasised here that one essential for success is a good facing layer of well-graded fresh, clean sand combined with the proper amount of cement and water. The re-use of the facing sand after the first mixing with cement results in a mixture having markedly lower strength and increased permeability even though as much new cement has been added as was used originally. It is doubtful whether the spent cement adhering to the sand grains can be removed sufficiently to return the sand to its original condition. The adhering cement separates the sand grains and not only reduces the strength and increases the permeability of the facing, but alters the surface characteristics and increases the undesirable lime constituents at the surface of the mould. This creates a condition favourable for burning-on and fusion with the steel. It, therefore, appears that uniformity in results can be obtained far more simply and more certainly, as well as more cheaply, by using the high-grade facing exclusively for each mould.

Recommendations

After carrying through a full scale research on the usual sand testing basis, the author makes the following recommendations:—

Portland cement may be used as a binder in foundry moulding sand. For the facing of the mould only fresh, clean, well-graded silica foundry sand should be used. The sand should be mixed with about 10 per cent. cement and a total of 4½ per cent. of water by weight of the dry materials. This damp mixture should be rammed in the usual manner and to the proper thickness. It can be backed up with a mixture composed of cement and a lower grade of sand or other material. Such a facing mixture, when made with high initial strength Portland cement and protected from loss of moisture for the first 24 hrs., will have excellent strength and permeability for foundry purposes, two or three days after moulding, even though dried rapidly following the initial 24 hr. moist period. If normal Portland cement be used, the green strength will be lower and a longer curing period and greater age will be necessary to obtain the same set strength. Increasing the amount of normal Portland cement would give adequate strength, but would bring about an undesirable decrease in permeability and increase the lime constituents at the surface of the mould.

The facing mixture may be mixed and rammed in the usual manner but extended milling should be avoided in order to reduce temperature rise and moisture loss. Mixtures at normal temperatures of 70 to 80 deg. Fah. should be rammed within 2½ hrs. after mixing if made with high early strength cement, and within 4 hrs. if made with normal Portland cement. Mixtures at higher temperatures, say 100 to 110 deg. Fah., should be rammed as soon as possible after mixing, but not later than one hour.

ROBSON REFRACTORIES, LIMITED, foundry engineers and consultants, Darlington, have now taken over the sale of German Chamotte, which is used for moulding and other purposes.

Testing Foundry Sands*

By W. Y. BUCHANAN

Introduction

The first part of this Paper is intended as a review of the apparatus[1] described in the author's first two Papers, after it has been in use for a number of years. The author has encountered much confusion in the minds of those starting sand testing, which in some cases is likely to result in their complete abandonment of control by this process.

The following comparison of the American Foundrymen's Association and British Cast Iron Research Association methods is intended to show why this disagreement exists. The author does not consider rapid testing in the shop necessary or likely to become general practice. The plant and shop management should be arranged to give the desired uniformity. Properly planned research on a scale to suit the requirements of the case is more likely to bring useful results, and much of the published data are spoilt by unsatisfactory testing, whilst some are definitely misleading and harmful.

Were the A.F.A. method used alone, the foundryman would carry on his testing in ignorance of the variables and errors, but when, as is the case at present, the suppliers furnish him with sets of both A.F.A. and B.C.I.R.A. apparatus, he uses both and becomes discouraged when they do not agree.

Green-Strength Testing

The testing frame of the present B.C.I.R.A. design is much improved on the previous form, and presents a steady pressure at right angles to the test-piece without any wabble. Unfortunately, the plates on these machines are not square, and to get them to work properly it is necessary to pack them up with pieces of tin. The plates are rather loosely secured, and, if turned round, they will rest in any angle but the horizontal. If the faces of the balance and cross-head of the machine are not parallel, the compression readings are low.

Permeability Test

Richardson's modification of the A.F.A. permeability apparatus was adopted by the Institute's Sands Sub-Committee, and is still in use, having been put on the market in much the same form as the original drawings. There appears to be some intention of putting forward some other modification of the A.F.A. apparatus. The new type of B.C.I.R.A. gas permeability apparatus was used for all the work recorded here, and use was made of a mercury seal and the standard double compression with a $2\frac{1}{4}$ by $1\frac{1}{8}$ in. test-piece. This method is not quite so fast as Richardson's, but is thought to be more reliable and convenient.

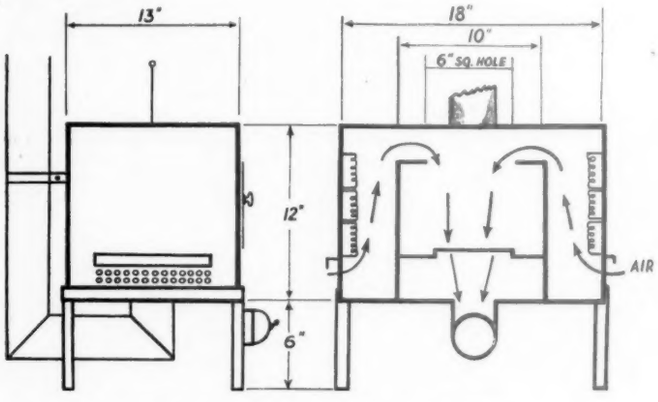

FIG. 1.—CORE DRYING APPARATUS USED.

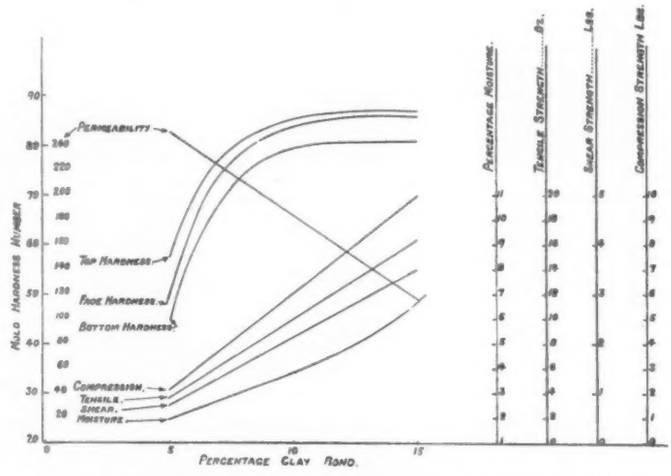

FIG. 2.—HARDNESS OF A.F.A. TEST-PIECE AS INFLUENCED BY CLAY (DIETERT).

The A.F.A. test-piece is not properly designed and really has no parallel in moulding, for no mould is filled and rammed with three blows. Skerl's hand-ramming method was undoubtedly the nearest to hand moulding, the weak link in the chain being that he credited the moulder with a great deal more skill than he actually possessed or more than a carefully-trained research worker could acquire in many years. The double compression method has its parallel in air squeezing machines. The moulds and plunger for this are generally very poorly made. The mould should be a steel tube, well finished in the bore, while the plungers should be case-hardened and accurately ground with a minimum of sliding clearance and having sharp and square ends. They should not be made in brass, nor should the tube be less than 8 in. long or the small piston less than 1 in. It is a mistake to shorten the tube, as it was originally designed to allow the sand to fall naturally into the tube and leave ample room for the piston. The flange should not be discarded, as it has many advantages.

Penetration Hardness Tester

The penetration hardness tester was never intended to replace Deitert's hardness tester, as the author was not aware that any such tester existed; in fact, when the first Paper on sand testing was prepared by the author, he did not know any details of the A.F.A. apparatus, and so had to devise a tester to suit the work in hand. However, having now used both extensively, comparison may be of interest. Any penetration testers which the author has seen are home made, but with a few precautions these should work perfectly.

The weight, which should fall quite freely and without friction on the wire or tube, should have its diameter and length about equal in preference to a long weight of small diameter. An engraved scale in millimetres should be fixed to the tube so that the penetration readings can be read more conveniently. It is not intended here to argue whether or not mould hardness will ever be controlled by testing in the foundry, but there is no doubt that by far the most important variable in the foundry is ramming, and this must be taken into account in all sand research.

Hand moulding shows more variation than machine or plate moulding. For instance, in green sand hand moulding the variation on one mould was 16 mms. max. and the maximum variation noted was over 55 to 22 mms. in a number of moulds. With dry sand hand moulding the maximum variation on one mould was 19 mms. and the maximum variation noted was 53 to 22 mms. With green sand plate moulding the maximum variation was 14 mms. and with green sand single squeeze moulding the flat surfaces give a maximum difference of 9 mms.

Drill Hardness Tester

The drill hardness tester is still the only method which can be used to investigate the ramming across sections of the same test-piece, or of dried specimens, such as oil sand, for the effect of local overheating. An illustration in a previous Paper by the author shows a piece of square oil-sand test-piece badly overheated on one side through being heated in a bottom heated electric oven; the strength on the overheated side would be about half of the proper value. Another illustration (*loc cit.*) showed a test throughout a double compression test-piece showing uniformity of hardness throughout. This drill hardness tester is the most suitable, although it is not the quickest method of measuring the flowability.

Flowability

The method suggested for testing the flowability of sand in the author's previous Papers seems still the best. A recent American method consists of ramming a 2-in. test-piece with four blows and then measuring how much it sinks with the next blow. This seems a rather clumsy and unnatural principle. The method now advanced is to use the standard B.C.I.R.A. test-piece, $2\frac{1}{4}$ in. by $1\frac{1}{8}$ in. dia., made by single compression, and then test the hardness top and bottom. Dietert's hardness tester may be used. In the green-sand and dry-sand samples referred to later in the Paper, the differences of 7.3 for dry sand and 13 for green sand give a measure of flowability. This can be done at the same "index of ramming"—to be referred to later—but may hold for the whole range of densities. The drill tester may also be used for this test and, though slower, may give better results. The load on the drill and number of turns are fixed, and the sand which is bored out by the drill is weighed in an analytical balance. The ratio—top to bottom—is a measure of the flowability, and a figure of 1:1 shows good flowability, whilst with a decrease in flowability the ratio becomes less than unity.

* A Paper read before the Falkirk Section of the Institute of British Foundrymen.

1 For a review of sand testing it is necessary to consult previous Papers by Hudson, Skerl, Ridsdale, the author, and others.

Dietert's Hardness Tester

The main claim for Dietert's hardness tester is the convenience in carrying it about, and that it can be applied to the sides of a mould. It requires calibration and will not work with the glass or celluloid cover in position, and without which it cannot be carried about in the pocket. As shown later it does not measure the true hardness but gives a skin hardness, part of which may be induced in the act of testing, and this figure does not often represent the degree of ramming in the adjoining layers owing, for instance, to sleeking.

When applying this skin hardness tester to the mould a slow application gives a much lower reading than when the application is rapid, the difference being about five. All skin hardness tests taken for this Paper were usually taken as the average of ten on the test-piece, i.e., five on top end and five on bottom. The penetrating tests were made one per test-piece and therefore the advantage is in favour of Dietert's apparatus in all comparisons. The cost of Dietert's tester is somewhat high and tends, by nature of the skin hardness measured, to show less difference in finished moulds than the proper mould hardness or penetration, i.e., it tends to show a regularity which does not exist.

Drying Oven

The oven illustrated in Fig. 1 has been in use about four years, and a number of people have been furnished with drawings and particulars, including the A.F.A., the Institute and the B.C.I.R.A. A specification in the A.F.A. standard sand methods which seeks to define an oven which will give uniform drying states: "It must be controllable up to 315 deg. C., and, when charged up with cores, must recover its temperature in less than 30 min. It must give five to eight changes of air per hour, and the cores must be able to be removed without disturbing the temperature." There is not another oven which really meets this specification. It heats to its full temperature in under nine min., gives the necessary changes of air, and recuperates in a few seconds, not 30 min., and cores can be removed without disturbing the temperature.

The principle is simple and is similar to the open-hearth furnace. The oven has a double U in the gas-flow system, with the heater elements in the first U, and the door in the second, so that it cannot affect the draft of the furnace. The natural flow of the first U goes on with the door open and the gases pass downwards through the test-pieces in parallel lines. When all the heaters are switched on, the oven heats to full heat rapidly, and when the heaters are switched off, the temperature is maintained steadily to 2 deg. C. on two elements. No automatic regulator is necessary, and, in any case, these regulators are expensive and do not work very well on heavy duty. By manipulating the resistance, any temperature can be maintained from 80 deg. C. to 360 deg. C., and by insulating the sides as well as the top, a higher thermal efficiency and higher temperature can be obtained.

The oven recovers its temperature very quickly, as the flow of gases is not disturbed by opening the door. The construction makes the core free from radiation heating, and in ovens heated from the bottom a fan becomes an absolute necessity to prevent overheating. No "chimney" is actually required; the height of 24 in. is quite sufficient, but as oil-sand cores give off quite large quantities of fume, it is better to fit a chimney to any type of electric oven.

The principle of having the heater at the bottom and air outlet at the top is quite wrong, and although it will not work without a fan, it does not follow that even with the fan the heating is as uniform as in the stove just described, in which radiation heating is entirely eliminated. The simple construction and low cost make construction and repairs easy. The elements are of the standard domestic fire type and all the partitions at the top and ends may be removed without having to loosen bolts or rivets.

Hydraulic Compression Testing Machine

The hydraulic compression testing machine has been used in sand testing for about four years, and has been recently adopted by a number of people. The machine is simple in principle, and consists of a small piston actuated by a fine screw and a floating piston of ten sq. in. area. The space between the pistons is filled with oil, and the pressure is read on a gauge. By turning the screw, pressures up to a total of 6,000 lbs. can easily be exerted on a test-piece. The gauge reading is then multiplied by ten. It has been difficult to satisfy all the requirements of the critics; for example, some require a pressure up to 4,000 lbs. and an accuracy below 50 lbs. on the same machine.

The leather bucket washer on the main piston was replaced by a sleeve-fitting piston which was made oil tight for high pressures. The bucket washer on the old piston spread at high pressures and increased the friction, giving very serious errors of varying magnitude.

Reference has been made to Dietert's small machine, which was taken from the principle of the hydraulic press, but all the modifications followed after this first machine had been made and drawings circulated. Ridsdale has since returned to this apparatus and has employed a

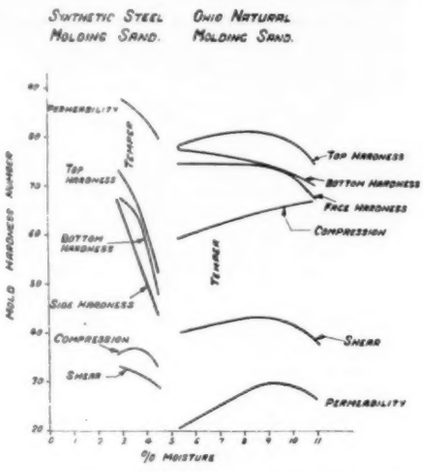

FIG. 3.—HARDNESS OF THE A.F.A. TEST-PIECES AS INFLUENCED BY MOISTURE (DIETERT).

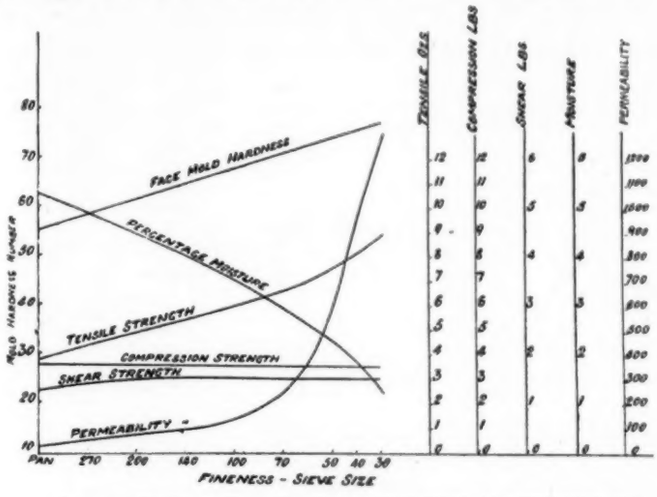

FIG. 4.—HARDNESS OF THE A.F.A. TEST-PIECE AS INFLUENCED BY FINENESS (DIETERT).

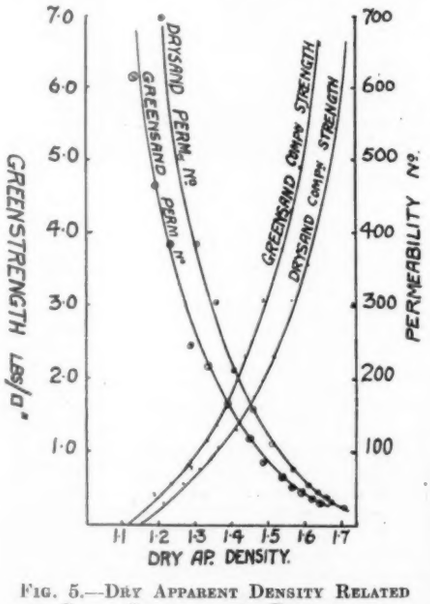

FIG. 5.—DRY APPARENT DENSITY RELATED TO GREEN STRENGTH AND PERMEABILITY.

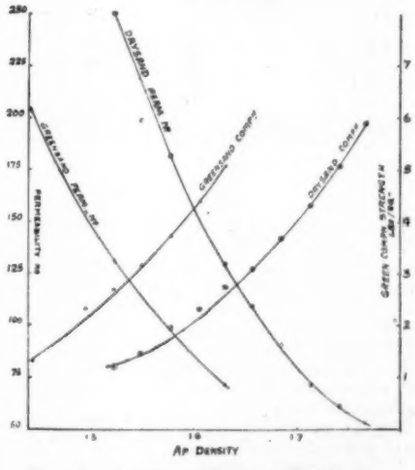

FIG. 6.—APPARENT DENSITY RELATED TO PERMEABILITY AND GREEN COMPRESSION STRENGTH.

rig to use a hydraulic jack, as illustrated in his article.[2] There seems no point in adding the levers, etc., to get tensile and shear tests, as these are not recognised by the Institute, and do not provide any information which is not already given by the compression test. It also apparently increases the cost of the machine considerably.

Moisture Test

To test the moisture content of sand by the standard weighing methods is still the most accurate method, and is quite convenient if the loss on ignition calculation is made also. The main objection to this method is the time required. The moisture tester recommended by the Institute's Sub-Committee is quite convenient for quick work, but is insufficiently accurate for research work. If the pressure gauge were fitted with a simple zero adjustment, such as a method of rotating the engraved dial as in Diertert's skin hardness tester, the user could reset the zero periodically and save trouble.

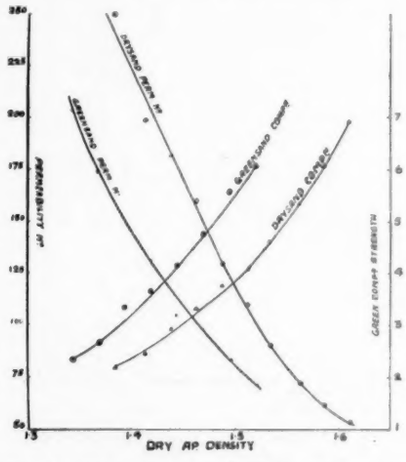

FIG. 7.—DRY APPARENT DENSITY CORRELATED WITH PERMEABILITY AND GREEN COMPRESSION STRENGTH.

Loss on Ignition

As indicated in a previous Paper (*loc. lit.*) the loss on ignition test is one of the best methods of gauging the available live bond in a foundry sand and several workers appear to have adopted it. The time result is, of course, masked by carbonaceous material, but it should be fairly easy to make a combustion train which would separate and weigh the combined water.

Definitions

Apparent Density or Green Apparent Density.—This is the weight in gms. per m.l. of the green test-piece and is naturally affected by a variation of the moisture content. The author's second Paper[3] contained a method of correction based on a carefully determined minimum workable moisture content, *i.e.*, 5 per cent. for Scottish rock sand and probably a similar quantity for other natural sands. This is simple and works quite well.

Dry Apparent Density.—This is the weight in gms. per m.l. of the green test-piece less the moisture content or the weight in gms. per m.l. of the dried test-piece.

True Density.—This is the ratio of weight of dry sand to the weight of the same volume of water at a given temperature (20 deg. C. being used for all the densities in these notes). The method using a large density bottle was intended to give the required accuracy with the usual sand testing balances, but these must be really accurate.

The densities given in Table I (except wood and sawdust) were carried out in a 50 gm. bottle weighing to 100.00005, *i.e.*, an accuracy of half the eighth figure for which the very best type of analytical balance was used. This class of work is, however, lessening the hope of the Institute's Committee to make sand testing methods to suit an intelligent labourer. The original trouble with this small bottle was air trapped in the sand, but this was overcome by covering the sand with water and then vacuum boiling, *i.e.*, placing the half-filled bottle in a vacuum chamber and holding until the small air bubbles had gone and the water boiled quietly. It is then filled with distilled water and carefully adjusted at 20 deg. C. in a thermostat or large volume of water at 20 deg. C.

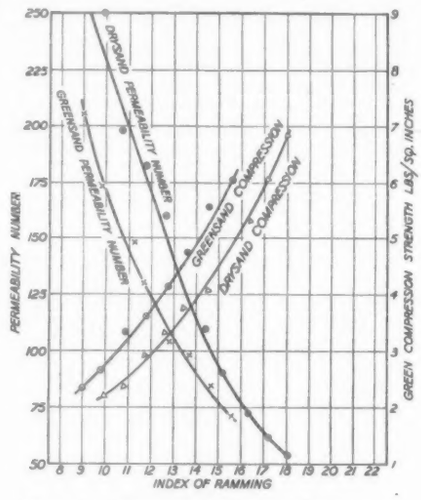

FIG. 8.—INDEX OF RAMMING RELATED TO PERMEABILITY AND GREEN COMPRESSION STRENGTH.

Index of Ramming

The system of testing the mould hardness (not skin hardness) and reproducing a test-piece of the same hardness is sound theoretically and practically. However, the question of variation of the true density of sand has been considered several times when speaking in favour of the A.F.A. drop ramming method, although no figures have been given.

The A.F.A. test-piece is subject to the effects of flowability, and does not give test-pieces of true standard ramming. It is vitiated by the variation of water, clay, fineness, and the addition of coal dust, and from a consideration of Figs. 2[4], 3[4] and 4[4], where the variation of hardness at the top and bottom will be noted, it is evident that a great part of the change in properties recorded (strength and permeability) are the result of th ereaction of the drop-weight rammed test-piece to changes in flowability rather than to the actual effect of the variable under examination.

To overcome this, the "index of ramming" method is suggested as being free from the effects of density and flowability alike. This is defined:

$$\text{Index of ramming} = \frac{\text{dry apparent density} - 42}{\text{true density}}$$

It is obvious that, when the dry apparent density falls below that at which the core can be handled, the zero of ramming is reached (Fig. 5). The upper limit is reached when the core can be compressed no further.

Consider for an example a dry sand and green sand which varies most in true density from the usual, and will therefore cover the extremes of true density variation.

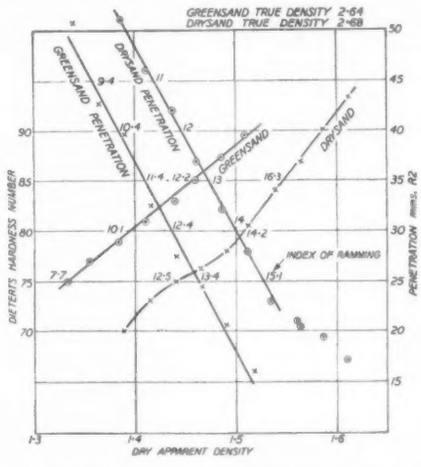

FIG. 9.—INDEX OF RAMMING AND MOULD HARDNESS COMPARED.

Note that the ratio $\frac{\text{dry apparent density}}{\text{true density}} = 42$ for both sands at no green strength, and the index of ramming gives a scale 0 to 20 over all possible degrees of ramming.

When testing the green sand and plotting the apparent density, the curves are wide apart and show the profound effect of the addition of coal dust. The graphs (Fig. 6) have not been corrected to 5 per cent. moisture.

In Fig. 7 the same results are plotted to dry apparent density and the difference in properties is much less, whilst in Fig. 8 the same results plotted to "index of ramming" show the difference in properties to be less than half by the other methods.

TABLE I.—*Densities of Various Materials.*

Material.	True density.	Material.	True density.
Levenseat—		*Kilwinning—*	
Rock sand	2.64	Washed white sand	2.65
Special fine rock sand	2.64	,, yellow sand	2.65
Fine washed sand	2.72	Tollcross sand	2.70
Coarse washed sand	2.71	Bishopbriggs sand	2.68
Fine milled sand	2.71	Irvine sea sand	2.68
Coarse milled sand	2.69	Belfast red sand	2.68
Steel moulding sand	2.66	Colbond clay	2.70
Erith—		Bentonite clay	—
Mild loam	2.65	"Silt" (variable)	2.57
Medium loam	2.64	Quartz	2.65
Extra strong loam	2.68	Coal (28.7 per cent. volatile matter)	1.38
Drumcavil rock sand	2.70	Yellow pine wood	0.41
Dullatur ,, ,,	2.69	,, ,, dust, in bulk	0.17

The A.F.A. Test-piece

The A.F.A. test-piece is deemed not to have been properly designed, and, as shown in the author's previous Paper (*loc. cit.*) is inferior in every way to the double compression test-piece. The results seldom agree with those obtained when using the B.C.I.R.A., owing to the many defects in the A.F.A. Even when the A.F.A.

(*Continued on page* 414.)

[2] FOUNDRY TRADE JOURNAL, January 21, 1937, page 85.
[3] FOUNDRY TRADE JOURNAL, March 16, 1933.
[4] From Dietert's Papers.

Production of Some Iron Castings for Steel Works*

By J. ROXBURGH

Many complete individual units comprise what is referred to generally as a steel works plant and each of these units has its own special features and pecularities of design and manufacture, according to the expert ideas of the manufacturer or user or both. Great strides have been made in the technique associated with the steel works and the manufacturer of the plant has improved his product to cope with modern demands.

The author is connected with a company, founded in the 18th century, the chief manufactures of which are rolling mill plant, continuous and semi-continuous, hydraulic plant and forging presses as well as other steel works plant. Although the company has separate steel, roll and iron foundries, the author proposes to confine his attention solely to the iron foundry, which is modern and up to date, having been built only 12 years ago. The iron foundry supplies castings to outside customers, as well as supplying the needs of the company's own engineering shops.

In surveying the requirements of steel works plant, as regards iron castings, it is of interest to record that, in England, a considerable quantity of the castings continues to be made in plain and alloy cast iron with and without steel additions to the mix, although there are many instances where steel castings are essential to cope

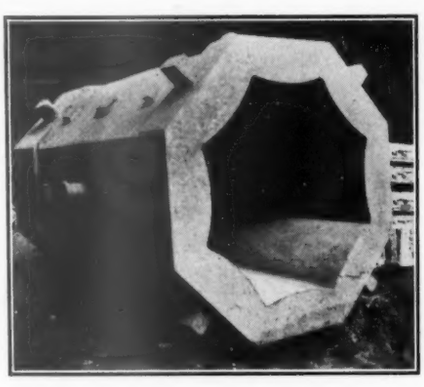

FIG. 1.—OCTAGONAL INGOT MOULD WEIGHING 60 TONS.

with the heavy duty they have to perform. The author's foundry is capable of dealing with castings from a few pounds in weight up to 60 tons, and, in addition to the castings for rolling mills, cylinders, rams and liners of all descriptions, anvil blocks, ingot moulds and accessories, slag pans, etc., are manufactured. A Paper such as this cannot deal with all these types of castings, so the author has selected certain definite castings for more detailed consideration.

After perusing literature connected with the iron and steel industries, it is disappointing to find that there has been very little matter published on the subject of ingot moulds from the manufacturer's standpoint, with the exception perhaps of Papers contributed by Blakiston[1] and Ballantine within the past two years. Due recognition, however, must be given to the amount of investigational work carried out by the users of ingot moulds, and it was only as recent as last year that Swinden and Bolsover[2] published an excellent Paper on the subject from that angle, while the work of the Heterogeneity of Steel Ingots Committee of the Iron and Steel Institute is well known and authoritative. They are all to be congratulated on their efforts in this direction as their work is undoubtedly of distinct interest to the industry and a desire for greater co-operation between the user and manufacturer, which is hoped will eventually lead to concrete developments, seems to be indicated.

An Ingot Mould is Primarily a Permanent Mould

As is probably well known, an ingot mould is primarily a permanent mould, supplied as a tool to the steelmaker. Into this mould the latter teems molten steel through the bottom and when solid gives him a steel ingot of a desired shape and weight. The steelmaker therefore designs the tool to meet his requirements as regards size, cooling rate of ingot, shape, solidity and soundness of ingot cast therein. Whether the mould be square, rectangular, slab, round, octagonal or duodecagonal, he determines the camber on the wall, the thickness of the walls, the radius at the corners, the capacity of the mould and any necessary lifting arrangements. Ingot moulds are made in this country varying in weight from a few pounds up to 150 tons, embracing many shapes and sizes, the section of metal varying from say 2 in. up to 24 in.

Quality of Ingot Mould Measured by Life

Naturally, the quality of an ingot mould can only be measured by the amount of service it gives to the steelmaker, and so it is obvious that the way to assess this is by counting the number of ingots that are made from the particular ingot mould, or, as commonly referred to, the number of "heats" or "lives." It is of interest to the manufacturer to know that the steelmaker keeps accurate records of the life of the castings. Yet this information is only available to the foundryman when some particular mould has failed prematurely and, in consequence, a complaint is registered. On the other hand, if he receives no news at all, he is at liberty to assume that, at least, the castings he has supplied are giving as good service to his customer as are those of his competitors.

Conditions of Service for Ingot Moulds

Before attempting to manufacture any type of casting, the conditions of service that the casting has to withstand must be thoroughly understood. The method of procedure in the steel melting shops will be considered briefly, although there are bound to be different methods prevailing in different firms. Some ingot moulds are coated on the inside surfaces with one of several types of facing material before being teemed into, while others, the author understands, are used in the condition as received, and, it is presumed, some attempt, whether done in a scientific manner or not, is made to preheat the casting. When the molten steel is run into the mould, the inner surfaces of the latter heat up very rapidly, which, in itself, is a shock to the casting. Time elapses for the passage of the heat through the walls and so the casting is unequally heated until such time as greater uniformity is reached, and thus the casting has to withstand this further attack upon it. Incidentally, it may be noted steel melts at 1,500 deg. C. and a hematite iron probably round about 1,150 deg. C.

When the ingot is solid and withdrawn, the mould is allowed to cool slowly or otherwise, according to practice. The particular mould may continue to be used regularly until its useful life is over, or, on the other hand, its use may be intermittent. In any case, it is obvious that the casting has to withstand a series of expansions and contractions during the course of its life. Another important feature is that the steel ingot produced must be sound, flat and smooth on all its surfaces and must be able to leave the mould without difficulty. The manufacturer of the ingot mould must, therefore, give very careful attention to the actual moulding of the casting and the question of the most suitable metal to meet the service conditions. Then he has to rely on the care exercised by the steelmaker in the treatment of his casting.

Those steelmakers who are responsible within their own organisation for the manufacture of ingot moulds for their own use, are naturally at an advantage. They can keep faithful records of the details of manufacture as well as of the ultimate service rendered by the castings. The jobbing ironfounder, who supplies ingot moulds to the steelmakers, can certainly standardise

FIG. 2.—METHOD OF MAKING INGOT MOULD CORE.

manufacture in his own foundry, but is dependent on the steelmaker for any information as to useful life obtained. He probably feels that, if he were to supply a special experimental mould to the steelmaker, it would seriously interfere with the repetition and continuity of the latter's daily programme.

It would appear, also, that each individual steelmaker has his own idea of design of ingot mould, of treatment before, during and after usage. There is, also, the question of different types of steel and their effect upon the life of moulds, and so, at times, it is rather confusing to the foundryman when one mould of a certain capacity give satisfaction to one steelmaker, while another mould of similar capacity, used in some other steelworks, has not given the same performance.

Metallurgical Aspects

Having dealt with the treatment meted out to the castings in the steel melting shops, the metallurgical aspects of the castings must be considered in detail. It would seem that there are many divergent opinions as to the most

* Exchange Paper presented on behalf of the Institute of British Foundrymen at the annual meeting of the American Foundrymen's Association in Detroit. The author is manager of the foundry and patternshop, Davy Bros., Limited, and Past-President, Sheffield Branch, Institute of British Foundrymen.

1 Blakiston, J., "Ingot Moulds, Bottoms and Slag Ladles," FOUNDRY TRADE JOURNAL, Vol. 52, February 28, 1935, pp. 153-154, and March 7, pp. 175-176.

2 "Some Notes on Ingot Moulds." Proceedings, Inst. of British Foundrymen, Vol. 28, 1934-35, pp. 192-248.

suitable metal for an ingot mould and research is still proceeding. Swinden, as a result of experience, dismisses the alloy iron mould, and favours high silicon (1.9 per cent.) and fairly low manganese (0.6 per cent.) and is commencing investigation on the higher manganese irons (1.75 per cent.). Blakiston, however, adheres to a silicon of 1.8 per cent. and manganese up to 1.2 per cent. They both advocate low sulphur and phosphorus although mentioning German moulds containing 0.2 per cent. phosphorus. Swinden can see little benefit from steel additions, while Blakiston uses up to 6 per cent. steel scrap in his mixtures and specifies above 3.5 per cent. total carbon in his iron.

To a certain extent, the mould manufacturer is in the hands of the steelmaker, as far as the metallurgy of the iron used is concerned as, in many instances, the mould, after its useful life, is melted up in the steel furnaces. For acid steel, this means that the material should contain 0.07 per cent. sulphur and 0.07 per cent. phosphorus as a maximum, although lower sulphur contents can be obtained, despite the fact that metal melted under cupola conditions picks up 0.03 per cent. sulphur. Be that as it may, the conditions of service of the ingot mould put definite limitations on the structure to be sought in the casting. The mould is subject to a series of expansions and contractions in the course of its life. It is, therefore, deduced that, under these very special conditions, a power of elasticity and recovery be imparted to the casting, that the metal should contain a low combined carbon and have a large percentage of free graphite. From this, then, a high total carbon content and sufficient silicon to precipitate a large proportion as free graphite is indicated.

FIG. 3.—LARGE 45-TON ANVIL BLOCK, SHOWING COTTER AND POPPET CORE HOLES.

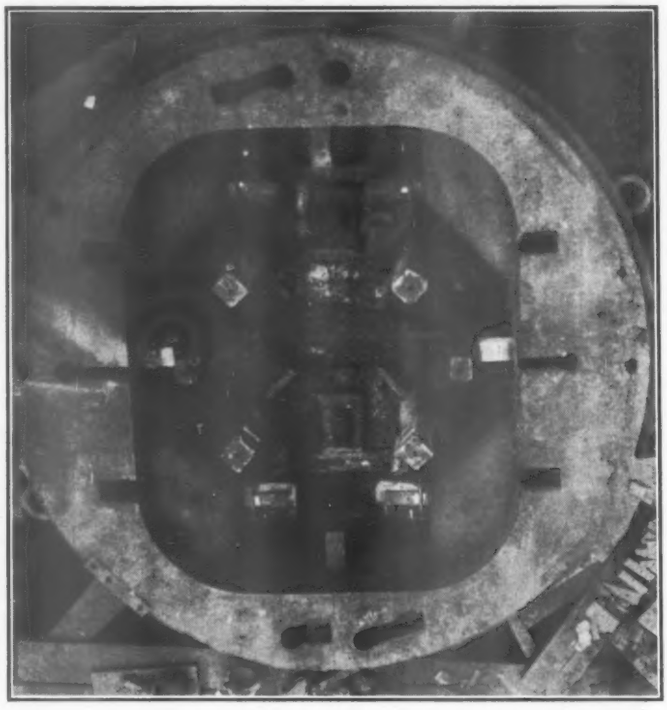

FIG. 4.—LOOKING DOWN INTO THE MOULD, SHOWING POPPET CORES IN PLACE.

This meets the situation as far as standing up physically to its work, but there is the chemical aspect to consider. These large graphite flakes, unfortunately, form inroads along which oxidation can and does take place, leading eventually to failure of the mould surfaces and the familiar "crocodiling" effect. The microstructure of an iron shows a large percentage of ferrite and graphite and a small percentage of pearlite, all constituents having their respective expansions, which, in itself, under conditions of service, causes breakdown of the surfaces. All these factors lead to the formation of oxides and finally fissures.

Combined Carbon and Graphite

In endeavouring to obtain a suitable structure in the casting, it would seem that it is a question of, first, how high can one go with the combined carbon content and, second, to what degree of fineness can one take the graphite present. The author recalls some ingot moulds he once made containing 3.0 per cent. total carbon, which cracked after only two heats and were beyond use. He decided that the low total carbon had caused the casting to be too rigid and lacking in ability to withstand the heating and cooling to which it was subjected. His experience on chills for chilled rolls bears this out too, as chills made for experiment, containing 3 per cent. total carbon, cracked early in life and were rendered useless.

If a high total carbon content be, therefore, advantageous, how can a finer graphitic structure be obtained, together with a low combined carbon in the resultant casting? It is recognised that when ferro-silicon is added to a material such as steel scrap where all the carbon is in the combined form, the resultant graphite produced is in a fine state of dispersion. Is there a white iron available, containing a high total carbon and a low sulphur and phosphorus? Would it be possible, for example, to experiment with a Swedish white iron, containing approximately 3.5 to 4 per cent. total carbon, 0.3 per cent. silicon, 0.5 per cent. manganese, 0.03 per cent. sulphur and phosphorus and add sufficient ferro-silicon to precipitate a large percentage of the carbon as graphite? Ferro-manganese would have to be added to adjust the manganese content. If this attempt prove that the structure is too close, then make various additions of hematite to increase gradually the size of the graphite. By adding ferro-silicon to the Swedish white iron, probably some of the carbon would be thrown out of solution, but the total carbon would still be sufficiently high. Other possibilities, such as an inoculated iron or the use of another type of melting medium, with higher temperatures and lesser contamination, should be considered.

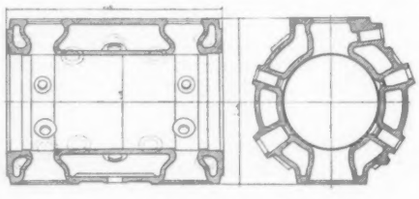

FIG. 5.—DRAWING OF GAS ENGINE CYLINDER SHOWING GENERAL DESIGN.

Manganese

With regard to the manganese content, the writer once supplied some small ingot moulds to a steelmaker, some containing 1.5 per cent., some 1.75 per cent. and some 2.0 per cent. manganese. It was reported to him that those containing 1.75 per cent. manganese had given an enhanced life and that 1.75 per cent. manganese seemed to be an optimum content. It is recognised that manganese above 1 per cent. imparts heat-resisting properties to the metal, under certain conditions, and that manganese, of that percentage, favours the retention of carbon in the combined form.

In the author's own experience, on large moulds a mixture of approximately 25 per cent. hematite scrap, 30 per cent. West Coast hematite (2.5 to 2.75 per cent. silicon and 0.5 per cent. manganese) and 45 per cent. East Coast hematite (1 to 1.25 per cent. silicon and 1.0 per cent. manganese) has been found to give satisfactory results. The ultimate analysis is above 3.6 per cent. total carbon, 1.6 to 1.8 per cent. silicon, 0.5 to 0.7 per cent. manganese, 0.07 per cent. sulphur max. and 0.07 per cent. phosphorus max.

The author supposes that it is only natural that each manufacturer of ingot moulds adheres to his favourite brand or brands of hematite pig-iron, and, undoubtedly, each brand possesses certain definite properties according to the ore from which it was smelted and to the conditions under which it was manufactured in the blast furnace. It would be interesting to collect data, if it were possible, on this matter.

Another point affecting the structure of an ingot mould is the treatment it receives in the foundry after casting, as regards the acceleration or prolongation in the cooling rate. The author makes a point of leaving his castings in

the sand for a more or less definite period, according to their size, as he feels that the natural cooling and annealing effects thus obtained are advantageous to the ultimate service life of the casting. With larger moulds the approximate procedure is to take 20-ton moulds out of the sand in two to three weeks, 40-ton moulds in three to four weeks and 60-ton moulds in four to five weeks.

Manufacture

It has been obvious in the survey thus far that, as far as the foundryman is concerned, his casting must be sound and dimensionally accurate,

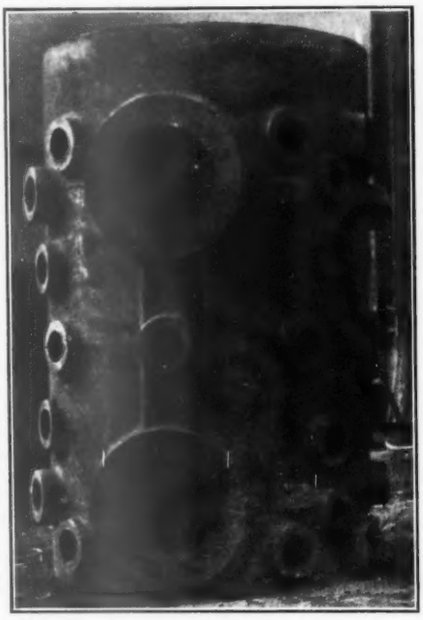

FIG. 6.—GAS ENGINE CYLINDER CASTING.

within foundry limits. The most important consideration is the inside of the ingot mould, which must follow the contour laid down by the designer, must be free from defects of any consequence, and must be flat, smooth and level on all inside surfaces. It is obvious that it would be useless supplying a mould with a wavy appearance or one with any holes or indentations inside, as this would interfere with the contraction of the ingot or would serve as a weak spot for the steel to attack. Again any chipping inside should be kept within bounds, as the destruction of the cast face is detrimental to its life.

Sand

Naturally, the methods of manufacture of ingot moulds vary from foundry to foundry, and each possesses its own technique as regards the type of sand used, the method of making the mould, the running of the casting, the casting temperature and the details of the tackle employed. In the first place, the question of a suitable sand for the core is of supreme importance and, again, the technique evolved often depends on the locality where the foundry is situated as, for economy, the possibilities of the nearest supply of sand are usually explored.

For smaller moulds, the sand must be capable of being sufficiently rammed and refractory enough to resist the pressure and temperature of metal and yet of the correct permeability to avoid scabbing. For these purposes, some people prefer a coarse, uniform-grained sand, strong in bond, while others prefer a very weak-bonded sand. Some cores are jolt rammed, some hand rammed and, in the latest development, Ballantine rams with sand both the moulds and cores for ingot moulds up to 30 tons in weight. For large moulds, the author's practice is to build both mould and core with Sheffield steel moulders' composition loam, a material of high refractoriness and able to withstand the pressure of large masses of metal.

Method for Large Ingot Mould

The author can only describe the methods and technique in his own foundry, which perhaps may not be the best methods, although he claims consistency in his results. The demands made upon the foundry in the case of a 60-ton mould are similar to those for a small mould in regard to degree of finish and accuracy of dimensions but, naturally, a 60-ton mould presents a much more responsible problem to the foundryman.

Pattern.—It is customary for the mould and the core to be built up as a loam job from a skeleton pattern and core frame. This 60-ton casting is octagonal in shape, both outside and inside (Fig. 1). The outside mould is constructed in a tanked pit, 15 ft. dia. by 14 ft. deep. The core has, in this case, 60 tons of metal around it and still has to leave the casting smooth, flat and free from defects of any consequence.

The Mould.—The bottom of the pit is rammed with sand and a bottom plate with eight lugs placed on this bed. A layer of bricks is laid thereon, interspersed with ashes, and the core print then bedded in. Next a level seating is struck on which the skeleton pattern is erected. This pattern consists of a top and bottom frame, carried with wooden "props." Bricking (the bricks used being soft and porous "clamps") is carried out to the top, with lugs, trunnions and in-gates built in their respective positions. It is usual practice to build up the mould in substantial building rings, 2 in. thick, the space between the outside of the bricks and the inside of the rings being rammed with sand. The bricks are faced with about 1 in. of loam, which consists essentially of Sheffield steel moulders' composition, the main components of which are old crucible pots and firebricks. After the mould has been completely struck-up, a straight-edge strickle guided by runners on the top and bottom frames is used. The skeleton pattern is then dismantled and withdrawn.

Finish.—The moulder now proceeds to finish the mould, then blacks it in the green state, the refractory facing used being mixed as follows: 225 lbs. of best-quality high-carbon blacking is mixed with thin claywash to a thick paste, and 7 lbs. of core gum, made with hot water is added. This paste is left to ferment for 48 hrs. and then wetted down with thin claywash to the desired consistency. Drying the mould is effected by means of a coke grid fire. Then the top plate, provided with holes for the runners and two risers is struck up with composition loam and put on the stove to dry.

The Core

The more important job is the making of the core. A bottom core plate with four staples, accurately cast from a pattern, and a corresponding top wooden frame, supported at the correct height and relative to the bottom core plate, is provided and a straight edge strickle is run on the outside of these two frames (Fig. 2). It is a difficult problem, however, to ensure a strong core and one, at the same time, able to take care of the contraction stresses.

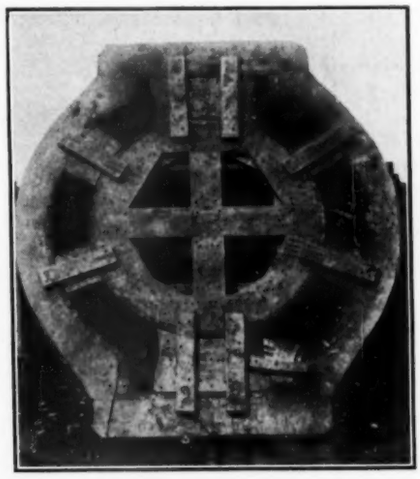

FIG. 7.—SEGMENT CORE BOX FOR JACKET CORE FOR GAS ENGINE CYLINDER.

With this in view, the core is built up with bricks and loam. Grids, with dabbers cast on, are placed at 8-in. vertical intervals, which materially strengthen the core. Loam bricks of special shape and size are inserted at the corners and centre of the flats of the core, with soft bricks in the intervening spaces, a procedure essential to ensure success.

Between the loam bricks at the corners, the space is rammed with core sand, so that pricking can be done through to the centre of the core for venting purposes. Again to prevent any irregular squeezing of the core, which would make it impossible to obtain the smooth surface insisted upon, the bricking should be carried to the dabbers of the grid. The core is faced with

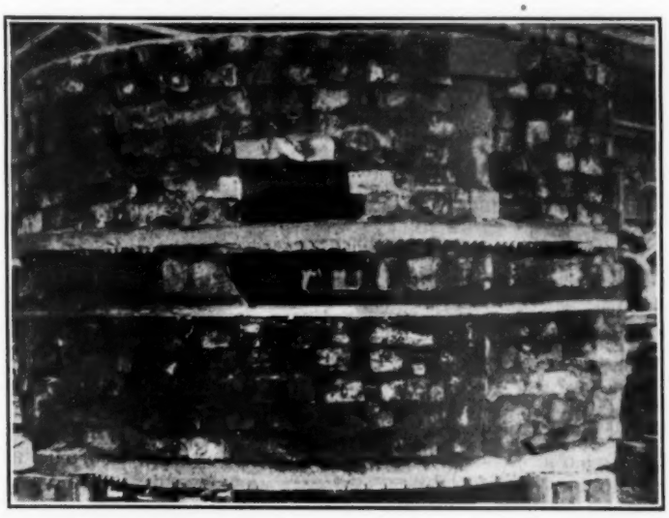

FIG. 8.—OUTSIDE OF THE MOULD FOR A GAS ENGINE CYLINDER.

1 in. of steel moulders' composition loam, finished, air dried and blacked with similar blacking to that used when finishing the mould while green. The core is then lifted from the staples on the lugs at the bottom core plate on to the stove for drying.

When closing, the core is accurately located in the print in the mould, and the inside of the core rammed up with black sand. Vents are brought up to the top. Special attention should be paid to this point, as the vent is made by ramming long rods inside the core and withdrawing them to provide outlets for the escape of gases.

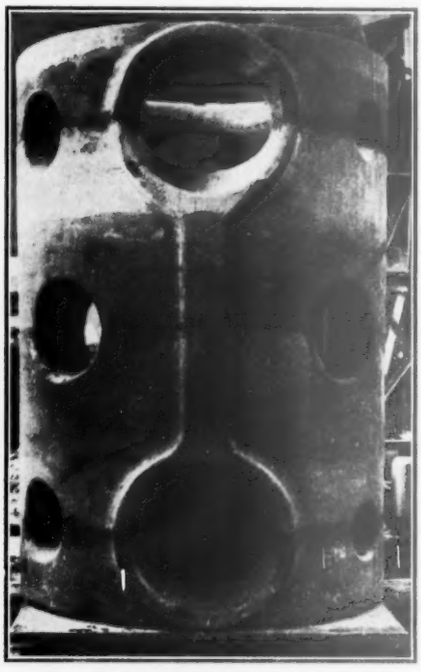

FIG. 9.—ASSEMBLED JACKET CORE FOR GAS ENGINE CYLINDER.

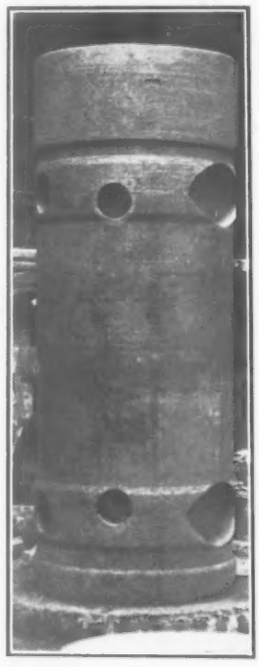

FIG. 10.—GAS ENGINE CYLINDER CENTRE CORE.

The top plate is next located and the core stamped so as to avoid any metal gaining access to the inside of the core. It is then packed and securely bolted to the lugs at the top building ring, which has previously been bolted down to the bottom plate. As an extra precaution, black sand is rammed in the pit round the outside rings to a depth of 4 ft. The runner dishes and riser bushes are placed in their respective positions and weights put on the top plate.

Gating

Too great importance cannot be attached to running such a casting and, in this case, three down-gates are used, necessitating three ladles and three cranes. The three ladles are of 30 tons, 22 tons and 16 tons capacity respectively. The in-gate from the 16-ton ladle, which is poured first into a spout runner, is placed 1 in. from the bottom of the mould. The in-gate from the 22-ton ladle, second to be poured, has two in-gates, one of which enters 2 ft. higher than the in-gate for the 16-ton ladle and the other 7 in. above half way up. The in-gate from the last ladle, the 30-ton, is placed half way up. In all cases, the down-gate should be 5½ in. dia. and the in-gates 6 by 2¾ in. to 5¾ by 2½ in. and set at a tangent to the mould so as to prevent the stream of metal directly impinging on the corners of the core and to impart a uniform swirling motion to the metal.

If this swirl is not maintained throughout the running, it will probably be found that some scum or dirt has been trapped against the core and so the higher level of in-gate speeds up the flow of metal, which, before it reaches the higher in-gate, is tending to lag. A 9-in. head is cast on the top end of the mould to ensure soundness after machining. There are two risers, also about 6 in. dia., which take approximately 2 hrs. to feed.

Possible Defects

Ingot mould castings are subjected, after fettling, to a very rigid inspection, when apparent defects are immediately brought to light. Occasionally, small holes are discovered, filled with sand, blacking or slag, or they may be clean holes. This points to dirty metal, bad running, scabbing or to the blacking being washed off if not sufficiently tight. Again, cold-lap marks may be evident due to dull metal. Casting temperature is important; usually, metal is melted at a high temperature and allowed to cool down to a definite temperature for casting.

Variation in dimensions across the flats is encountered and, with a large mould, this may reach $+\frac{3}{8}$ in., and may be due in some degree to inaccuracies in moulding, to the settling of the core and to lack of uniform contraction. At times a slight camber on the vertical faces inside the mould is discovered and this may be due to the contracting and squeezing. Another defect, not so easy to explain, is the occurrence of small blacking scabs in the corners of the inside of the ingot moulds. Some attribute it to casting temperature, some to method of application of blacking, by which several coatings of blacking exist so that the metal gets behind the top one. Others believe that, due to the squeeze in contraction, the corners get squeezed to a great extent, which disturbs the blacking, causing the metal to penetrate. Personally, the author finds that, with a properly dried core and the proper sand control, this defect is rare.

It will be realised that the subject of ingot moulds is full of possibilities of research and discussion. Essentially, the steelmaker wants something better from the foundryman, who, however, without full knowledge of the service conditions, is at a serious disadvantage. It is, therefore, necessary for the steelmaker to standardise his practice in regard to ingot moulds and then to acquaint the foundryman with full particulars so that the latter can deal with the matter scientifically.

Anvil Blocks

It cannot for a moment be said that a 45-ton anvil block is a difficult job to mould, as far as skill in actual moulding craft is concerned. At the same time, unless the correct procedure is adopted and suitable materials made use of, dire results are certain to accrue. In the block under consideration, there are six poppet and six cotter cores. The latter are 7 by 2 in. and extend 9 in. through the poppet cores. In addition, there are numerous other cores of varying shapes and sizes (Fig. 3).

At one time, it was permissible to reinforce such cores with cast-iron casing 2½ in. thick. However, it was found that, in actual service, these castings formed a weakness in the block, leading to its premature cracking. To-day, these cores are made from a special refractory material without any superficial reinforcements and can be fettled out comparatively easily. With the use of pneumatic tools, it is possible for two fettlers to fettle such a block completely in eight working days. On the behaviour of these sand cores, subjected to a high temperature and surrounded by a large mass of metal, depends, to a great extent, the success of the job, and it is gratifying to record that these anvil blocks have been made successfully over a long period.

FIG. 11.—SMALL CORES LOCATED IN PROPER POSITION IN GAS ENGINE CYLINDER MOULD.

Equally important, of course, is the metal used

for such a block as well as the solidity and soundness of the casting. It is usual to allow 1 in. machining on the top side of the block and to place a 16-in. dia. riser on the centre for feeding purposes. The feeding operation takes 10 to 12 hrs.

Realising the service demanded of this block, it is obvious to the founder, that a high-quality iron is required, although the engineer has designed a very heavy large-section casting to cope with the heavy duty. To-day, usually, a definite analysis is specified to be worked to. A

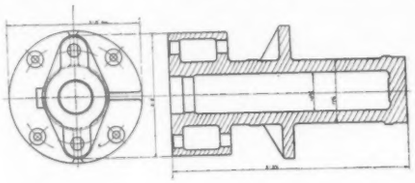

Fig. 12.—Drawing of Low Pressure Intensifier Cylinder.

typical specification for such a casting is:—T.C, 3 to 3.25; Si, 1 to 1.2; Mn, 0.5 to 0.7; S, 0.06 to 0.09; and P, 0.4 per cent. max. The analysis of the metal, however, is not the only factor to be considered and is merely a guide. The irons constituting the mixture and the conditions of melting are equally or more important. With cupola-melted metal, the author has used successfully a mixture consisting of 16 per cent. steel rail ends, 20 per cent. East Coast hematite (1 to 1.25 per cent. Si and 1 per cent. Mn), 16 per cent. cylinder iron, 16 per cent. steel scrap, and 32 per cent. machinery scrap. This mixture on a recent cast, yielded the following analysis:—T.C, 3.06; Si, 1.07; Mn, 0.60; S, 0.090, and P, 0.36 per cent.

The author has obtained 30 per cent. of the total weight of iron required from the air furnace where, it is well known, a reduction of total carbon, silicon and manganese takes place and that no gain is registered in the sulphur content, all of which help to produce a refined iron. For all low-silicon mixtures in his foundry, the author makes use of the chill test and, in the case of this block, a depth of chill of 1 to 1¼-in. is usually recorded. Probably a metal with a lower silicon content, and consequent greater chill depth on the test-piece, would be considered more suitable for a casting of such a large mass of metal. However, the time for the collection of metal and the running of the casting has to be taken into consideration. The analysis previously stated is eminently suitable both from the point of view of structure and of life.

Pattern and Mould Making

The important features of the manufacture of the casting must be given attention. A full pattern is usually provided with the necessary coreboxes. A bottom plate is bricked, and irons built in the brickwork at definite places to permit, at a later stage, bolting down of the various cores. Core prints are bedded in and a coating of loam struck on. In all cases, therefore, prints are made bigger than the actual core size, and the cores are constructed with a foot piece to fill these corresponding prints. These feet provide a good foundation for the cores to stand upright and also help to keep the cores in position when the metal runs over them. The pattern is then put on this seating and bricked up to the joint. As an extra precaution, provision is made for bolting back those cores which fit into prints on the side of the mould.

Another important point to note is the specially-made top plate provided with holes to correspond with the poppet cores thus to allow them to come through and to expand without hindrance and also for the vent to escape easily. When closing the bottom part of the mould (Fig. 4), a wooden template supplied to centre the poppet cores will be found extremely useful so that they will pass through the top plate when finally placed. The mould is built up in building rings 2 in. thick and top plate bolted down to the bottom plate.

Core Procedure

The manufacture of the cores is really the most important operation and the refractory used has for its chief constituent silica rock, which is mixed with "compo" and other ingredients and milled. Loose irons alone are used for reinforcing the poppet and cotter cores and the latter, after drying and cooling, are painted, first with black paint and then with silica paint. A very hard core indeed is obtained in this manner. Its refractoriness under load is excellent and no fritting takes place when the metal comes in contact. These cores have good surfaces when fettled out as this is as essential as dimensional accuracy. Due attention, therefore, must be paid to the refractory materials

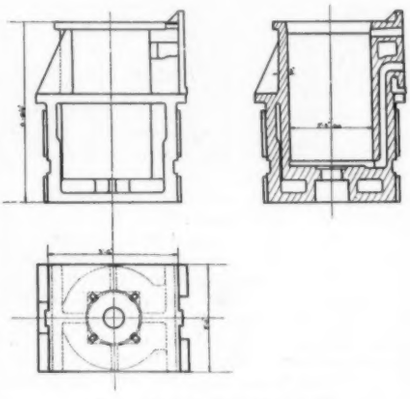

Fig. 14.—Steam Hammer Cylinder.

used and to the bolting of the cores in position in the mould so that they are not disturbed in any way.

The author has dealt with the precautions which must be observed in the manufacture of this 45-ton block, together with the metallurgical aspect, and, by paying strict attention to the details enumerated, such castings can be made successfully as a routine job.

Gas-Engine Cylinder Procedure

The gas-engine cylinder illustrated in Fig. 5 weighs approximately 14½ tons when finished and is 8 ft. 2⅝ in. long, and I.D. 3 ft. 7⅞ in. In a preliminary consideration to the moulding of this job (Fig. 6), there are three main parts:—(1) The outside mould, (2) the centre core and (3) the jacket core. It is necessary that each of these portions should consist of four parts, split at the same joints so that all the cores may be

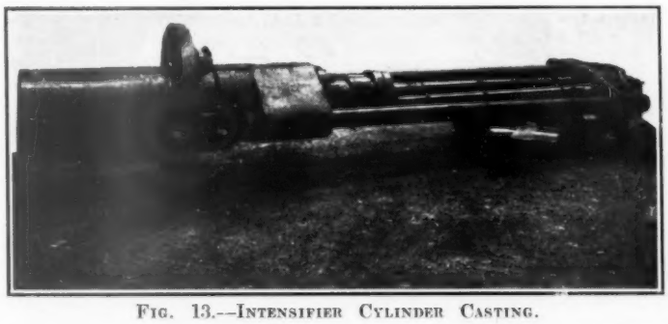

Fig. 13.—Intensifier Cylinder Casting.

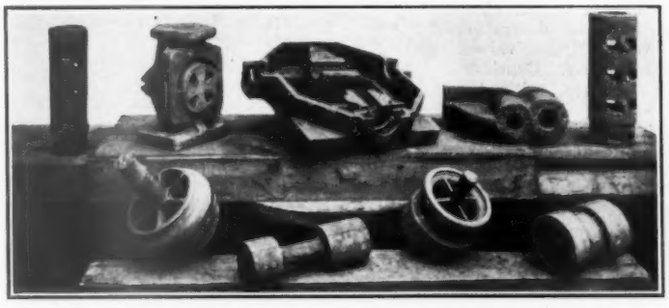

Fig. 16.—Small Castings requiring Special Attention to ensure Soundness and Cleanness.

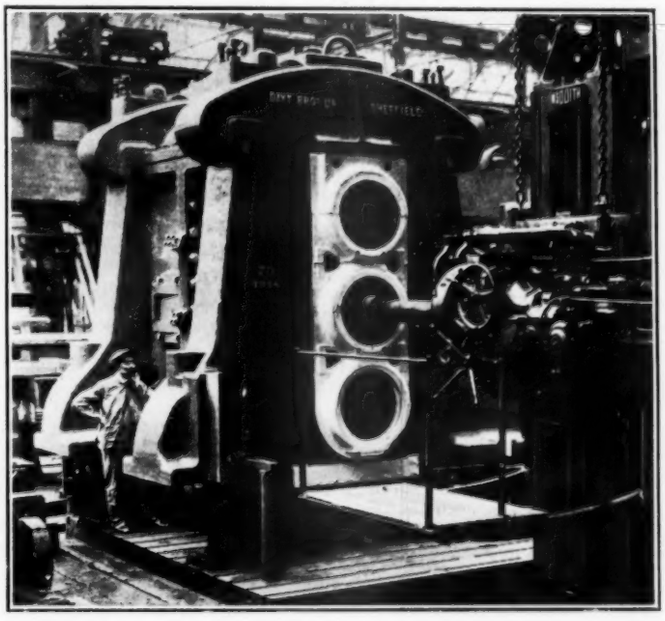

Fig. 15.—Pinion-Housing, in Halves, and Housing Cap, the Total Weight of which is 70 tons.

put in position during the closing operations. Regarding the leading off of the vent from the jacket core, where possible, advantage is taken of those cores cutting through on the outside of the mould and, as an extra precaution, six cores, 2½ in. dia., are taken off the top of the jacket core through the head and afterwards plugged up. A 12-in. head is incorporated on the top of the casting to ensure solidity.

The running is effected by two down-gates, 2½-in. dia., on opposite sides of the casting, with tangentical in-gates entering at the bottom. Nineteen tons of metal are required, equal amounts in each ladle. During pouring, when the metal has reached approximately halfway, six top gates, 2¼ by ⅝ in., are released down the bore only.

The pattern tackle supplied consists of loam tackle, boards, loose chests, loose bosses for the outside and centre core and two segment core boxes for the jacket core (Fig. 7), The outside of the mould consists of four parts, each carried with a joint plant. One row of bricks only is built, spaces being left where necessary to take off the vents (Fig. 8). After closing, cast-iron rings are put round, the space between the brickwork and rings being filled up with black sand and ashes.

Cores

The jacket core is made with oil sand, sea sand being used with a proprietary oil compound. The core is made in four pieces, each core being reinforced with a cast-iron grid. The joint of each core is made perfectly level and the whole core assembled before closing and rubbed where necessary to ensure accuracy and alignment (Fig. 9). The centre core is bricked up separately in four pieces, a cast-iron plate carrying each part and prints are embedded in where required (Fig. 10). When closing, the bottom tier of the outside mould is laid in the pit and the first layer of the centre core located in the print. Four cast-iron screwed studs are placed in the bottom of the mould and then the first piece of the jacket core is supported on these studs.

All the small cores are then placed in position (Fig. 11). Each tier of outside centre core and jacket core is built up likewise, and each time the small cores are located. As each segment of the jacket core is assembled, a level joint is ensured and stamped, and six vents from the ashes are led up to the six 2½-in. dia. cores at the top, in which pipes are inserted to lead off the vent. On the top of the jacket core, four cast-iron screw studs are placed, packed to the core iron and eventually to the top plate to prevent lifting of the jacket core.

The Metal

The mixture of the metal used for this casting is: Remelt iron, 16 per cent.; mottled iron, 16 per cent.; cylinder iron, 24 per cent.; steel-mix scrap, 20 per cent.; and cylinder scrap, 24 per cent. A recent analysis showed:—T.C, 3.06; Si, 0.98; Mn, 0.48; S, 0.090; P, 0.32 per cent., giving 1 in. on the chill test. The metal in the bore of the cylinder is 2½ in. thick, when finished, and shows on machining a dense close material.

Liner for Gas-Engine Cylinder

The liner for a gas-engine cylinder is 1 in. thick when machined, and 4½ ft. long. A 12-in. head is cast on to ensure cleanliness and solidity. The outside is rammed up from a wooden plug pattern and the core is struck up separately with a $\frac{7}{16}$ in. metal allowance left all over for machining. The method of running adopted is a down-gate with a tangential in-gate entering at the bottom to form a cushion of metal before eight top gates 2 by ⅜ in. are released. A similar analysis is required as for the cylinder with the exception that the phosphorus is usually kept at 0.25 per cent.

Intensifier Cylinder

The intensifier cylinder is of the low-pressure type, demanding a test pressure of 1 ton per sq. in. Here, again, the composition of the metal as well as the soundness of the casting are important. The walls of the cylinder, it will be noted, are 3¼ in. thick (Figs. 12 and 13).

These cylinders are moulded horizontally in suitable cylinder boxes made specially for the job. The mould is closed horizontally and the main core held in position with chaplets. It is then placed vertically for casting. A 2-ft. head is incorporated on the closed end to ensure solidity. These castings are run from the bottom with a tangential in-gate to ensure that the metal is given a spinning action.

For such castings, a close-grained structure is essential and, with this in mind, low carbon, a low silicon and low phosphorus are sought in the metal. A suitable mixture is made with steel scrap, mottled iron, cylinder iron and cylinder scrap. The chill test obtained on a recent cast was 1⅛ in., the analysis being:—T.C, 2.92; Si, 0.74; Mn, 0.5; S, 0.092; and P, 0.20 per cent.

Other Types of Castings

Many types of cylinders and rams are made in the author's foundry, and an example is shown (Fig. 14) of a steam-hammer cylinder containing port cores. Detailed attention must be paid to the moulding, the methods and cleanliness of running, and to the metallurgical aspect in all cases to ensure success. An illustration is shown (Fig. 15) of a pinion housing, in halves, and a housing cap, the total weight being 70 tons. Such castings are usually bedded in the floor and a box part used for ramming the top. Good results have been obtained by mixing a small quantity of ganister with the sand used for the top part, to strengthen the sand. A steel-mix iron is invariably used to give an approximate analysis of:—T.C, 3.25; Si, 1.20; Mn, 0.6; S, 0.08, and P, 0.4 per cent. This mixture consists of 20 per cent. steel scrap, 20 per cent. East Coast hematite (1 to 1.25 per cent. Si and 1.0 per cent. Mn), 20 per cent. steel-mix scrap, and 40 per cent. machinery scrap.

A 50-in. roll-lathe bedplate is 32 ft. long and weighs approximately 15 tons. The slides, of course, are cast face downwards, and must give good wearing surfaces. A steel-mix iron is used for this casting, and it is interesting to record that a ¾-in. camber was required on this bedplate casting.

A few examples of small castings, which require special attention to ensure sound, clean castings are shown in Fig. 16. The illustration includes valve liners, drop valves, lifting valves, valve bodies and bevel gear housing. Considering the valve liner, for instance, with the rectangular ports, this casting is moulded horizontally and cast vertically with a runner through the centre of the core, and a strainer core is used in the bush, thus ensuring freedom from dirt in the casting. Naturally, in all cases, the metal must be cast at a high temperature and, where the castings require machining all over, special methods of running are employed. Nickel, chromium and molybdenum either separately or together are incorporated in certain alloy cast iron mixtures for castings demanding special service conditions.

In conclusion, the author wishes to take this opportunity of publicly thanking his directors and Mr. W. Reid, general manager, Davy Bros. Limited, Sheffield, for permission to publish this Paper, and would convey most hearty and cordial greeting to the members of the American Foundrymen's Association.

DR. WILLIAM HUME-ROTHERY, Warren Research Fellow of the Royal Society, has been elected a Fellow of the Royal Society. Dr. Hume-Rothery has been responsible for extensive research designed to elucidate the physical structure of alloys and other metallurgical systems.

Testing Foundry Sands

(*Continued from page 408.*)

test-piece is made by double compression, the results are not as accurate as they should be. This additional plunge was suggested in the previous Paper, and has been put on the market, but the author does not know of anyone attempting to use it. The A.F.A. method has been carefully tested for a number of years with various rammers, and the present results have been done under the best conditions available, so that the above opinions are as favourable as possible. The A.F.A. test on the green sand and dry sand samples gave the following results:—

	Green sand.	Dry sand.
Green strength (lbs. per sq. in.)	4.72	4.33
Permeability	101	121

The hardness by Dietert's method, 80 for the top and 84 for the bottom for green sand, shows uneven ramming, and 81 for the top and 74 for the bottom for dry sand shows a variation of uneven ramming with the type of sand.

The index of ramming in the A.F.A. test was found to be 10.8 for green sand and 11.6 for dry sand, showing that the A.F.A. method does not produce a standard ramming. If one is measuring the difference in properties of these two sands, then the above difference of index ramming would give a permeability difference of 27 by the A.F.A. test and 55 by the same index of ramming, and for green strength 0.3 lb. by the A.F.A. method and 0.65 lb. by the same index of ramming. This shows a 50 per cent. error in the A.F.A. method. These A.F.A. test-pieces gave a penetration hardness of 30 mms. for green sand and 37 mms. for dry sand. The double compression test-piece gave uniform ramming, as shown by Table II.

TABLE II.—*Ramming Results Using the Double Compression Method.*

Apparent dry density.	Dietert's skin hardness No.		
	Bottom.	Top.	
1.612	91	94	Dry sand, 8.615 per cent. H_2O.
1.562	87	88	
1.513	83	83	
1.463	77	77	
1.413	71	71	
1.516	89	90	Green sand 7.00 per cent. H_2O.
1.465	86	86	
1.415	81	81	
1.364	74	74	

Double compression using ½-in. distance piece on B.C.I.R.A. test-piece.

Comparison of Sands at the Same Hardness

It was thought that a comparison of these sands at the same index of ramming would be the same thing as comparing them at the same mould hardness (not skin hardness), but, as is shown in Fig. 9, there is a constant difference in penetration hardness; for example, at index of ramming 12, results of 28.5 and 40 mms. are obtained for green sand and dry sand respectively. Thus, for the same index of ramming the penetrating hardness is greater in green sand due to the fine coal dust closing up the sand. Where the grain size remains the same, the index of ramming is probably measured directly by the penetrating mould hardness. Considering the skin hardness graphs, it will be seen that for the same hardness number the difference of index of ramming is much greater and varies in the higher densities; that is, it is not proportional to the ramming and is unsound in principle.

(*To be concluded.*)

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ESTABLISHED 1910

The Week's News in Brief

Trade Talk

EXTENSIONS HAVE BEEN MADE at the Peterborough works of Baker, Perkins, Limited.

THE NORTH BRITISH LOCOMOTIVE COMPANY, Glasgow, has received an order for 30 duplicate locomotive boilers for the South African Railways.

ORDERS FOR TWO cargo motorships have been placed with Alex. Stephen & Sons, Limited, Linthouse, by the P. & O. Steam Navigation Company. Each vessel will have a gross tonnage of about 3,000.

AT A MEETING, held in Swansea on May 14, foundrymen in West Wales applied to the Welsh Engineers' and Founders' Association for an increase in their wages of 4d. per hour. The application is being considered.

E. LEITZ (LONDON) are holding an exhibition of metallurgical microscopes at the Cutlers' Hall, Sheffield, from May 25 to 28, and in the Royal Station Hotel, Newcastle, from June 1 to 4. The exhibition will be open in each case from 10 a.m. until 6 p.m.

DAVY & UNITED ENGINEERING COMPANY, LIMITED (formerly Davy Bros., Limited), Park Ironworks, Sheffield, now act as sole selling agents for the subsidiary company, Davy & United Roll Foundry, Limited (previously the British Chilled Roll & Engineering Company, Limited).

FORTY-ONE EMPLOYEES at the Leigh Works, Lancashire, of Callender's Cable & Construction Company, Limited, have been presented with £5 each in recognition of having completed over 25 years' continuous service with the company. Long service illuminated certificates are also to be presented to these men by the chairman.

INCREASES IN WAGES have been granted to the apprentices of Fairfield Shipbuilding & Engineering Company, Limited, Glasgow. The new rates are 12s. 6d. for the first year, 15s. for the second year, 17s. 6d. for the third year, 21s. 6d. for the fourth year, and 26s. for the fifth year. These represent advances of 2s. 6d. to 10s. a week.

JOHN BOWES & PARTNERS, LIMITED, have appointed **James** Hargreaves & Sons (Leeds), Limited, of 7, Victoria Street, London, S.W.1, as sole sale agents for Marley Hill patent coke in London and the South. Messrs. Hargreaves have retained the services of Mr. Denis Waters, who will continue to attend to all sales of Marley Hill coke in this area.

PROPOSALS FOR new industries at Jarrow were outlined by Sir John Jarvis when he visited the town last week. The proposals were, he said, to lay down a steel melting plant of the most modern type; to group round it a number of industries for which it would provide the raw materials; to start five such industries, embracing steel castings; the making of high hardness rolls by a process new in this country; the manufacture of axle boxes by a patent process, and the development of new methods of refining iron and, in addition, the manufacture of high grade tubes. These were all ideal for Jarrow, he said, because they would provide work quickly in weeks rather than in years; they were metal industries with which Jarrow men would be acquainted; they were better than one large undertaking, the failure of which might bring ruin again to Jarrow, and they would find work for between 900 and 1,000 men. As the result of negotiations, he had purchased the whole of the Armstrong-Whitworth business at Gateshead and also the pneumatic tool and air compressor business at Scotswood. That would mean that several hundred Gateshead men would not lose their jobs and that Jarrow would benefit by sharing the technical, administrative, and selling organisations of this old-established company.

Combating Waste and Increasing the Quality of Castings of Magnesium Alloys

A review is given of the technical processes of casting magnesium alloys in sand moulds according to American and European practice by A. S. Lugasskov in "Liteynoye Dyelo." The causes of wasters and methods of their elimination are analysed. The heat-treatment of magnesium alloy castings as a means of increasing their durability is discussed. The method of casting and refining by means of gases and the application of alloys which are inert to oxygen as a means of improving the quality of the castings are described.

Personal

MR. ROLAND STARKEY has been elected a director of Turner & Newall, Limited.

LORD WEIR, P.C., G.C.B., chairman of G. & J. Weir, Limited, Holmhead Foundry, Cathcart, celebrated his 60th birthday on May 12.

MR. T. G. PALMER, of Craigmore, Harrowby Road, Grantham, has relinquished his post as secretary to Aveling-Barford, Limited, after 32 years' service.

MR. JAMES TENNENT, of Airdrie, managing director of R. B. Tennent, Limited, Whifflet Foundry, has been appointed a Justice of the Peace for Lanarkshire.

MR. ALFRED ROWE BELLAMY, M.I.Mech.E., a director of Ruston & Hornsby, Limited, has been presented with the honorary freedom of the Borough of Grantham.

MR. A. H. MOORE, director of the Standard Brass, Iron & Steel Foundry, Benoni, Transvaal, and honorary member of the Council of the Institute of British Foundrymen, has arrived in England.

MR. G. L. BALL, melting-shop manager at the works of the South Durham Steel & Iron Company, Limited, who has taken up a new post with Brown Bayley's Steel Works, Limited, Sheffield, received a presentation from the men of the melting shop at the Steelworks Institute, West Hartlepool.

SIR CHARLES CRAVEN, chairman and managing director of Vickers-Armstrongs, Limited, received the freedom of the borough at Barrow recently, in recognition of the conspicuous part he has played in promoting the industrial prosperity of the town and the generous support he has given for the welfare of the inhabitants.

Wills

LANE, WILLIAM ROSS, of Bridge of Allan, ironfounder	£63,901
BURCHELL, C. T. D., chairman of Beyer Peacock & Company, Limited	£2,638
BOLTON, THOMAS, a director of Thomas Bolton & Sons, Limited, copper and brass manufacturers, Widnes	£54,345
HARVEY, G. A., founder and chairman of G. A. Harvey & Company (London), Limited, Greenwich Metal Works ...	£38,527
KENDRICK, WALTER, of West Bromwich, for twenty years general manager of Ridgacre Foundry Company, Limited	£2,573
SADLER, W. F., of Millom, for many years a leading official of Vickers-Armstrongs, Limited, at Barrow, and in 1923 appointed a special director ...	£12,628

Obituary

MR. WILLIAM DICKIE, founder of the firm of William Dickie & Sons, engineers and ironfounders, of East Kilbride, Lanarkshire, has died. He was 85 years of age.

THE DEATH HAS OCCURRED of Mr. Thomas Ferlie, a member of the firm of Robert Ferlie & Son, ironfounders, of Auchtermuchty, and an ex-Provost of the burgh. He was 74 years of age.

MR. SAMUEL EWART, chairman and joint managing director of Ewart & Son, Limited, and a director of Federated Foundries, Limited, and Saunders & Connor (Barrhead), Limited, has died, aged 65.

MR. JAMES LONGSON, of Chapel-en-le-Frith, died recently, at the age of 79. He was for some time the head of the firm of J. Longson & Son, ironfounders, a business which was founded by his father.

WE VERY SINCERELY REGRET to announce the sudden death of Mr. G. B. R. Taverner, managing director of British Pigirons, Limited, of Abbey House, 2, Victoria Street, London, S.W.1, last Thursday. During a recent visit to Belgium we heard from his agent that he was ill. On returning we naturally sent a letter of sympathy, but in reply received a note stating he was quite fit, having well recovered from a slight heart attack. Taverner was not the type to worry about his health, and perhaps was inclined to neglect it. He was an engineer by trade, having served his apprenticeship with Vickers, Limited, of Erith. He later worked at the Whitehead Torpedo Company, Limited, both at their Weymouth and Fiume factories. Prior to the outbreak of war, he was associated with James Chesterman & Company, Limited, of Sheffield. In 1914, he joined the Artillery, and left the Army with the rank of major in 1919. After a further period with the Sheffield firm, he joined the Frodair Iron & Steel Company, of London. About 1923, in conjunction with Mr. Thos. M. Willis, he formed British Pigirons, Limited. This company has been particularly successful, and has established trading relationships in many parts of the world, whilst at the same time building up a strong home business. His cheery personality will long be missed in foundry circles. He was an enthusiastic supporter of technological advancement, and his firm was a member of the British Cast Iron Research Association, and he personally of the Institute of British Foundrymen and the Iron and Steel Institute.

Company Reports

Atlas Steel Foundry & Engineering Company, Limited.—Interim dividend of 2s. per share.

Peglers, Limited.—First and final dividend of 1s. 6d. per 5s. "A" and "B" ordinary share.

Triplex Foundry, Limited.—Dividend on the ordinary shares of 7½ per cent. for five months to March 31.

Mason & Burns, Limited.—Dividend of 12 per cent. actual for the period from the date of incorporation, July 27, 1936, to March 31, 1937.

Harland & Wolff, Limited.—Profit on trading for 1936, before providing depreciation, £64,047; credit balance after crediting interest received, dividends on investments and the amount brought in, £203,881. During the year £1,715,100 was received from the liquidators of David Colville & Sons, Limited, on account of the company's holding in that company. This amount of cash, together with a further sum since received, has made it practicable to deal with the claims of the company's creditors and the reorganisation of the company's capital. Meetings of shareholders to consider proposals for the reorganisation of the capital are called for June 3.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Sussex Ironworkers, Limited, 14b, North Street, Eastbourne.—Capital, £500. Directors: G. P. Chapman and W. E. Millsom.

Baring-Gould & Partners, Limited, 25, Victoria Street, London, S.W.1.—Capital, £100. Consulting engineers, etc. Director: R. A. Baring-Gould.

Yannedis & Company, Limited.—Capital, £15,000. Ironfounders, etc. Directors: P. C. Yannedis, 10, Broomwater West, Teddington; H. F. S. Emerson, Marjorie Murray, H. T. Stagg, and F. S. Willcox.

Beryllium Corporation of Great Britain, Limited.—Capital, £1,200. To acquire mining leases of properties containing beryllium ore granted by the Portuguese Government, etc. Subscribers: E. L. Gray, 7, West Savile Road, Edinburgh; G. J. Nimmo.

Contracts Open

Doncaster, June 16.—18,000 yds. of 18-in. cast-iron water mains, for the Doncaster and Tickhill Joint Water Board. D. Balfour & Sons, consulting engineers, 3, St. Nicholas Buildings, Newcastle-upon-Tyne. (Fee £10, returnable.)

Newcastle-under-Lyne, May 31.—3,650 yds. of 21-in., 18-in., 15-in., 12-in., 9-in. and 6-in. dia. cast-iron, concrete tube and stoneware pipe sewers, for the Town Council. Willcox, Raikes & Marshall, engineers, 33, Great Charles Street, Birmingham. (Fee £5 5s., returnable.)

Forthcoming Event

Institute of British Foundrymen

JUNE 8 TO 11.

Thirty-fourth Annual Conference in Derby.

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Raw Material Markets

Makers continue to be heavily committed and do not appear to be eager to increase their commitments at the present time. It is hoped that producers will have larger outputs available for disposal over the second half of the year.

Pig-Iron

MIDDLESBROUGH.—No alterations have as yet been made in the prices of foundry iron, but an announcement is expected shortly. Meanwhile, business is restricted. Makers are so heavily booked that they are not in the position to accept fresh inquiries, even at the prices ruling at the time of delivery. It is hoped that supplies from the Midlands may be forthcoming as soon as the new prices are published. Both home and export orders for hematite remain on a heavy scale, but preference is being given where possible to consumers in this country, although export inquiries are at considerably higher figures. The revised scale of prices has had the desired effect of making new business possible to some extent, and several makers have accepted contracts involving deliveries over the second half of the year. East Coast mixed numbers are quoted at 122s. 6d. per ton, less 5s. rebate, delivered on the North-East Coast, 128s. at Sheffield, 133s. 6d. in the Midlands, and 120s. in South Wales.

LANCASHIRE.—Stocks at the consuming plants generally are low, and users who require additional supplies of pig-iron have to rely on the furnaces. Some consuming plants are not in the position to operate to full capacity because of the shortage of supplies. Until new quotations are announced prices of Midland common irons are only nominal. For delivery in the Manchester area, Scottish No. 3 is quoted around 134s. per ton, with West Coast hematite at 131s. and East Coast at 130s. 6d., both less 5s. per ton rebate.

MIDLANDS.—With new business right out of the question and deliveries on a rationed basis, the market in this area has been quiet, and will continue so until the higher quotations are made known. It is anticipated that this will be done within a week or so. Derbyshire producers are more heavily committed than are the Northamptonshire makers, and it is hoped that the latter will be able to offer substantial tonnages as soon as the new figures are brought into operation. Prices at the present time, of course, are purely nominal. Only meagre tonnages of the higher-grade irons are offered on the market, although deliveries against contracts are fairly good. Low-phosphorus iron is quoted at from £6 to £6 10s., with refined iron at from £7 15s. to £8 10s. per ton delivered the Midlands. While the new hematite price list allows the transaction of additional business, contracts are being restricted to tonnages based on previous requirements. However, this is a considerable improvement on the conditions recently prevailing. For delivery to Birmingham and district, West Coast mixed numbers are quoted at £6 14s. 6d. and East Coast No. 3 at £6 13s. 6d., subject to 5s. per ton rebate.

SCOTLAND.—Some hematite makers are willing to enter into business for delivery up to the end of the year. There continues to be little foundry iron on the market, and home-produced supplies are being supplemented by Continental material. No. 3 foundry iron is quoted at 113s., with 2s. 6d. extra for No. 1. Cleveland foundry iron continues to be quoted at 84s. f.o.t. Falkirk and 87s. f.o.t. Glasgow. These prices are purely nominal, however, as there is no iron on the market. Hematite and basic are 123s. and 107s. 6d. respectively, less 5s. rebate.

Coke

The question of prices continues to dominate the foundry-coke market. For delivery to Birmingham and district, best Durham coke is officially quoted at 46s. 6d. per ton, minimum, with Welsh coke at from 47s. 6d. to 60s., according to quality. At the present time, however, Durham coke is being disposed of at around 50s., and it is suggested in some quarters that the official price will be increased on June 1.

Steel

Little relief has been afforded to the market by the publication of the revised price list, and it is still extremely difficult to enter into new contracts for the supply of steel. In many cases producers have fully disposed of their outputs right up to the end of December. Any supplies that do become available are immediately taken up, but generally existing contract commitments more than account for the full production. Prices are a secondary consideration, and consumers would in many instances pay higher figures if they could be assured that the material would be forthcoming.

Scrap

It would appear that the control scheme for steel scrap sales has now been put into operation in most areas. Although there may be still a few minor details to be considered, the scheme is nearer to completion than ever before. It is reported from the Cleveland area that steel scrap prices are now fixed up to the end of the year, the basis figure being regarded as 67s. per ton delivered works. Prices, of course, are to be adjusted according to quality. It remains difficult to obtain supplies, and, although a substantial tonnage is being bought abroad, this material costs considerably more than the home prices. An increased turnover has been put through in South Wales at the new official levels. Consumers naturally welcome the opportunity to be able to procure larger tonnages. Supplies are also more freely available in the Midlands, Yorkshire and Lancashire, where buyers have heavy requirements and are consequently not slow to take every advantage of the new and improved conditions. Prices are well maintained in Scotland, and consumers are anxious to acquire all possible supplies. Although a larger tonnage is on the market, the demand remains well in excess of the supply.

Metals

As might have been expected, business sessions on the London Metal Exchange during the past week have been very quiet, and daily turnovers have been small.

Copper.—New York advices state that world stocks of refined copper on April 30 amounted to 283,000 tons, compared with 308,000 tons at the end of March. The apparent world consumption for April was 217,000 tons, compared with 211,000 tons for March. The world output by mines and smelters totalled 216,000 tons, compared with 204,000 tons. World production of refined copper during April amounted to 192,000 tons, compared with 191,000 tons in March. Supplies of refined copper are difficult to acquire, either in this country or in the United States. Consumption has been heavy in the past, but producers have not remained idle and outputs have been increased to a large extent. It is next to impossible to procure prompt supplies of copper at the present time. With regard to the question of copper restriction, it is reported from New York that discussions for the reimposition of restriction on copper production are going on at present. It is said that there is a considerable opinion in favour of a return to the 105 per cent. quota. Should a decision eventuate, the announcement is expected to be made in London. The opinion that excessive prices checked consumption and were therefore bad for trade, was expressed by Sir Godfrey B. H. Fell at the recent meeting of the Indian Copper Corporation. The recent fall in the price of copper was welcome, he said. The Ned. Kabelfabriek, in Holland, has erected a copper rolling mill and a 24-hour day is being worked.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £62 to £62 2s. 6d.; Friday, £61 15s. to £62; Tuesday, £62 15s. to £63; Wednesday, £63 15s. to £64.

Three Months.—Thursday, £58 to £58 2s. 6d.; Friday, £57 to £57 5s.; Tuesday, £58 5s. to £58 10s.; Wednesday, £59 7s. 6d. to £59 10s.

Tin.—Conditions in this market during the past week have been dull and there is little prospect of any immediate revival. American interest also has been rather quieter, but industrial activity in that country is heavy and on an expanding scale, the tinplate trade setting the pace.

Official quotations were as follow :—

Cash.—Thursday, £250 to £250 10s.; Friday, £249 to £249 10s.; Tuesday, £249 10s. to £250; Wednesday, £254 to £255.

Three Months.—Thursday, £247 5s. to £248; Friday, £242 15s. to £243 5s.; Tuesday, £245 5s. to £245 10s.; Wednesday, £250 5s. to £250 10s.

Spelter.—Holiday influences have prevailed in this market and buyers have displayed little active interest. This is somewhat disappointing, as more inquiries had recently been received. Consumers generally have well-filled order-books and are not likely to remain without making further purchases for any considerable time. The British Metal Corporation, Limited, announces that spelter output in the United Kingdom during the first quarter of the year was 15,496 tons, against 16,404 tons in the last quarter of 1936. An expansion of 3,000 tons occurred in consumption in the first three months of 1937 at 56,000 tons, against 53,000 tons in the closing quarter of 1936. Individual consumption figures for the chief trades are as follow:—Brass, 16,500 tons in January/March and 14,000 tons in October/December; galvanised sheets, 11,500 (12,000) tons; other galvanising, 11,500 (11,000) tons; oxide, 7,000 (7,000) tons; rolling, 5,500 (5,000) tons; miscellaneous, 4,000 (4,000) tons. The foregoing statistics indicate that in most trades consumption was only maintained, but a welcome improvement was noted in the galvanising industry.

Daily market prices :—

Ordinary. — Thursday, £22 10s.; Friday, £21 17s. 6d.; Tuesday, £22 3s. 9d.; Wednesday, £22 18s. 9d.

Lead.—This market has remained steady, but the outlook is not too promising. Consumers are not expected to enter the market for any substantial tonnages for a considerable time. New business in the United States is not heavy, but deliveries under existing contracts involve a good tonnage. The cable and battery makers, particularly, are active.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £23 12s. 6d.; Friday, £22 18s. 9d.; Tuesday, £22 12s. 6d.; Wednesday, £23 11s. 3d.

Aluminium.—Consumption of this metal continues to increase rapidly, and it is expected that a new high record will be established for the current year. Germany and the United States are leading the way, as they did throughout 1936. Aluminium foil has been tested in Germany and found suitable for the packing of butter, which is sensitive to light and air. In Japan, the rearmament programme is responsible for the use of a large tonnage of aluminium, and it is reported that prices are likely to be raised. It is estimated that Japanese demand in 1937 will amount to about 20,000 metric tons, while production in that country is not likely to be above 10,000 tons. Last year Japan imported 9,095 tons of aluminium.

Prices are unchanged.

Applications for Trade Marks

The following list of applications to register trade marks has been taken from the "Trade Marks Journal" :—

"ALIZAL."—Aluminium wares. Benjamin Electric, Limited, Brantwood Works, Tariff Road, London, N.17.

"CUPROTECTIC." — Metallic alloys containing copper. British Oxygen Company, Limited, Thames House, Millbank, London, S.W.1.

"FERROTECTIC."—Metallic alloys containing iron. British Oxygen Company, Limited, Thames House, Millbank, London, S.W.1.

"STALPAX." — Metal doors. Light-Alloys, Limited, Alpax Works, St. Leonards Road, Willesden Junction, London, N.W.10.

"TERRABOND."—Metals. I.C.I. Metals, Limited, Imperial Chemical House, Millbank, London, S.W.1.

"METALECT."—Electric furnaces. Metalectric Furnaces, Limited, Cornwall Road, Smethwick.

Base Metals and N.D.C.

A memorandum has been sent to the Chancellor of the Exchequer on behalf of a number of companies operating base metal mines abroad but administered from England, setting out views on the proposed N.D.C. as affecting their industry. The companies are concerned mainly with the production of copper, lead, zinc, and tin. The memorandum draws particular attention to the pressure that will arise for the transfer abroad of the control of these undertakings, and refers to the consequential loss of income-tax to the Exchequer and the diversion from the United Kingdom of the commercial activities of these companies, which are large buyers of machinery, plant, and supplies.

For **"easy stripping"** use

YORKSHIRE SAND

Yorkshire Sand is of a synthetic nature, its production being under careful laboratory control. Perfect standardization is obtained with the various grades, suitable for light and the heaviest steel castings.

It is because of the refractoriness of the sand and of the toughness of the mould surface that castings made with Yorkshire Sand are distinguishable by their excellent finish.

Please address all enquiries to the nearest Sales Office :

GENERAL REFRACTORIES LTD.,

Genefax House, Sheffield

Telephone : Sheffield 31113 (6 lines). *Telegrams : "Genefax, Sheffield."*

LONDON OFFICE: Russell House, Adelphi, W.C.2.
Telephone: Temple Bar 7361. Telegrams: "Genefax, Rand-London." Mr. A. C. Turner.

SCOTTISH OFFICE: 48, West Regent Street, Glasgow. Telephone: 3009. Telegrams: "Genefax, Glasgow." (Mr. C. A. G. Thomson.)

MANCHESTER OFFICE: 9, Albert Square, Manchester, 2. Telephone: Blackfriars 6130. Telegrams: "Genefax, Manchester." (Mr. S. G. Throssell.)

SWANSEA OFFICE: Metropole Chambers, Wind Street, Swansea. Telephone: 3680. Telegrams: "Genefax, Swansea." (Mr. D. Hood-Williams.)

CARDIFF OFFICE: 17, Windsor Place, Cardiff. Telephone: 5796. Telegrams: "Genefax, Cardiff." (Mr. F. E. Rutter.)

MIDDLESBROUGH OFFICE: Halifax Buildings, Exchange Place.
Telephone: Middlesbrough 3313. Telegrams: "Genefax, Middlesbrough."

★

Read what an IMPORTANT STEELFOUNDER says :—

"During the 40 years I have been connected with Steel Foundry work, considerable changes have taken place. Away back, we had Steel Moulders' Composition, Old Crucible Pots, etc., and each works claimed to have its own 'secret' moulding composition. High Silica Sand has eliminated practically all these from many foundries and to-day we have your 'Yorkshire Sand' which acts almost like a chill, and leaves the skin of the casting blue-black and as clean as cast iron.

The hot steel lies quietly against the wall of sand, and often when the casting has been lifted out of the mould, the latter looks as if it could be used over again, just like a permanent mould."

RAW MATERIALS—PRICE LIST

(Wednesday, May 19, 1937)

COPPER

	£	s.	d.
Standard cash	63	15	0
Three months	59	7	6
Electrolytic	64	0	0
Tough	65	5	0
Best selected	65	15	0
Sheets	66	0	0
India	78	10	0
Wire bars	67	0	0
Ingot bars	67	0	0
H.C. wire rods	70	10	0
Off. av. cash, Apr.	62	12	1 10/11
Do., 3 mths., Apr.	60	18	6 21/22
Do., Sttlmnt., Apr.	62	11	8 5/11
Do., Electro, Apr.	67	10	8 3/11
Do., B.S., Apr.	67	14	2
Do., wire bars, Apr.	68	9	1 1/11
Solid drawn tubes			14½d.
Brazed tubes			14½d.
Wire			10¾d.

BRASS

Solid drawn tubes	12¼d.
Brazed tubes	14¼d.
Rods, drawn	11d.
Rods, extd. or rlld.	7¾d.
Sheets to 10 w.g.	10¾d.
Wire	10½d.
Rolled metal	9¾d.
Yellow metal rods	7¾d.

TIN

	£	s.	d.
Standard cash	254	0	0
Three months	250	5	0
English	254	10	0
Bars	256	10	0
Straits	255	15	0
Eastern	253	0	0
Banca (nom.)	255	10	0
Off. av. cash, Apr.	267	8	7 7/11
Do., 3 mths., Apr.	264	4	10 7/11
Do., Sttlmt., Apr.	267	7	11 5/11

SPELTER

	£	s.	d.
Ordinary	22	18	9
Remelted	21	0	0
Hard	19	10	0
Electro 99.9	25	12	6
English	24	0	0
India	20	0	0
Zinc dust	25	0	0
Zinc ashes	9	5	0
Off. aver., Apr.	26	5	7 7/11
Aver. spot, Apr.	26	4	3 9/11

LEAD

	£	s.	d.
Soft foreign, ppt.	23	11	3
Empire (nom.)	23	7	6
English	25	10	0
Off. aver., Apr.	25	18	11 3/22
Aver. spot, Apr.	26	0	3 9/22

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

Zinc sheets, English	36	10	0 to 37	0	0
Do., V.M. ex-whse.	36	10	0 to 37	0	0
Rods			30	0	0

ANTIMONY

English	85	0	0 to 86	0	0
Chinese, ex-whse.			70	0	0
Crude, c.i.f.			37	0	0

QUICKSILVER

Quicksilver	15	12	3

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—					
25%	13	0	0 (nom.)		
45/50%	10	15	0 to 12	0	0 (nom.)
75%	15	15	0 to 17	0	0 (nom.)
Ferro-vanadium—					
35/50%			12/8 lb. Va		
Ferro-molybdenum—					
70/75% carbon-free			4/9 lb. Mo.		
Ferro-titanium—					
20/25% carbon-free			9d. lb.		
Ferro-phosphorus, 20/25%			£21 to £22		
Ferro-tungsten—					
80/85%			.5/- lb. (nom.)		
Tungsten metal powder—					
98/99%			.5/3 lb. (nom.)		
Ferro-chrome—					
2/4% car.	32	17	6		
4/6% car.	22	10	0		
6/8% car.	21	10	0		
8/10% car.	21	10	0		
Ferro-chrome—					
Max. 2% car.	32	10	0		
Max. 1% car.	35	15	0		
Max. 0.5% car.	36	10	0		
70% carbon-free	9½d. lb.				
Nickel—99.5/100%	£180 to £185				
"F" nickel shot	£165	0	0		
Ferro-cobalt, 98/99%	7/3 lb.				
Metallic chromium—					
96/98%	2/5 lb.				
Ferro-manganese—					
76/80% loose	£16	15	0 to 17	5	0
76/80% packed	£17	15	0 to 18	5	0
76/80% export	£20	0	0		
Metallic manganese—					
94/96% carbon-free	1/3 lb.				

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 7d.
Finished bars, 18% tungsten	3s. 6d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 5/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel	3	8	0 to	3	10	0
Mixed iron and steel	3	5	0 to	3	7	6
Heavy cast iron	3	8	0 to	3	10	0
Good machinery	3	15	0 to	4	0	0
Cleveland—						
Heavy steel				3	7	0
Steel turnings				2	12	6
Heavy cast iron				4	5	0
Heavy machinery				4	7	6
Midlands—						
Short heavy steel				3	15	0
Light cast-iron scrap				3	5	0
Heavy wrought iron	3	17	6 to	4	2	6
Steel turnings	2	2	6 to	2	5	0
Scotland—						
Heavy steel	3	4	6 to	3	7	0
Ordinary cast iron	4	7	6 to	4	10	0
Cast-iron borings	2	0	0 to	2	2	6
Wrot-iron piling	4	5	0 to	4	7	6
Heavy machinery	4	13	6 to	4	15	0

London—Merchants' buying prices, delivered yard.

Copper (clean)	48	0	0
Brass	30	0	0
Lead (less usual draft)	19	0	0
Tea lead	12	0	0
Zinc	13	0	0
New aluminium cuttings	74	0	0
Braziery copper	43	0	0
Gunmetal	45	0	0
Hollow pewter	155	0	0
Shaped black pewter	110	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	83/6
,, No. 3	81/-
,, No. 4	80/-
Forge No. 4	80/-
Hematite No. 1	123/-*
Hematite M/Nos.	122/6*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	123/-*
,, d/d Birm.	134/6*
Malleable iron d/d Birm.	—
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	83/-
,, No. 3 fdry.	86/-
Northants forge	80/6
,, fdry. No. 3	83/6
,, fdry. No. 1	86/6
Derbyshire forge	83/-
,, fdry. No. 3	86/-
,, fdry. No. 1	89/-
Scotland—	
Foundry, No. 1, f.o.t.	115/6
,, No. 3, f.o.t.	113/-
Cleveland No. 3, Glasgow	87/-
,, ,, Falkirk	84/-
Scottish hem. M/Nos. d/d	123/-*
Sheffield (d/d district)—	
Derby forge	80/6
,, fdry. No. 3	83/6
Lincs forge	80/6
,, fdry. No. 3	83/6
W.C. hematite	128/6*
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	89/-
Staffs fdry. No. 3	89/-
Northants fdry. No. 3	87/6
Cleveland fdry. No. 3	89/-
Glengarnock, No. 3	134/-
Clyde, No. 3	134/-
Monkland, No. 3	134/-
Summerlee, No. 3	134/-
Eglinton, No. 3	134/-
Gartsherrie, No. 3	134/-
Shotts, No. 3	134/-

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)				11	17	6
Nut and bolt iron	10	5	0 to	10	15	0
Hoops				12	15	0
Marked bars (Staffs) f.o.t.				14	7	6
Gas strip				12	15	0
Bolts and nuts, ¾ in. × 4 in.				17	10	0 and up.
Steel—						
Plates, ship, etc.	11	8	0 to	11	10	6
Boiler plts.	11	18	0 to	12	0	6
Chequer plts.				13	0	6
Angles				11	0	6
Tees				12	0	6
Joists				11	0	6
Rounds and squares, 3 in. to 5½ in.				12	0	6
Rounds under 3 in. to ¼ in. (Untested)				11	9	0
Flats—8 in. wide and over				11	5	6
,, under 8 in. and over 5 in.				11	10	6
Rails, heavy				10	2	6
Fishplates				14	2	6
Hoops (Staffs)				12	4	0
Black sheets, 24g. (4-t. lots)				15	15	0
Galv. cor. shts. (,,)				19	10	0
Galv. flat shts. (,,)				20	0	0
Galv. fencing wire, 8g. plain				17	10	0
Billets, soft, 100-ton lots				7	17	6
Sheet bars				7	15	0
Tin bars				7	15	0

PHOSPHOR BRONZE

	Per lb. basis
Strip	13¾d.
Sheet to 10 w.g.	14¼d.
Wire	15¼d.
Rods	15¼d.
Tubes	20¼d.
Castings	16d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
to 10g.	1/6½ to 2/1½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/5½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.76
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	95.00
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.15
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb box	$5.35

COKE (at ovens)

Welsh foundry	32/6 to 35/-
,, furnace	27/- to 28/-
Durham foundry	34/6
,, furnace	32/6
Scotland foundry	—
,, furnace	28/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	24/6 to 25/6
,,	28×20 ,,	49/- to 51/-
,,	20×10 ,,	34/6 to 35/6
,,	18¾×14 ,,	24/9 to 25/9
C.W.	20×14 ,,	22/- to 23/-
,,	28×20 ,,	45/- to 46/6
,,	20×10 ,,	31/- to 32/6
,,	18¾×14 ,,	23/- to 25/-

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£12	0	0 to £13	0	0
Bars-hammered, basis	£20	0	0 to £21	0	0
Bars and nail-rods, rolled, basis	£19	0	0 to £20	0	0
Blooms	£16	0	0 to £17	0	0
Keg steel	£27	0	0 to £30	0	0
Faggot steel	£20	0	0 to £25	0	0
Bars and rods dead soft st'l	£19	0	0 to £20	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£	s.	d.		
May	13	62	0	0	inc.	25/-
,,	14	61	15	0	dec.	5/-
,,	18	62	15	0	inc.	20/-
,,	19	63	15	0	,,	20/-

Standard Tin (cash)

		£	s.	d.		
May	13	250	0	0	inc.	45/-
,,	14	249	0	0	dec.	20/-
,,	18	249	10	0	inc.	10/-
,,	19	254	0	0	,,	90/-

Spelter (ordinary)

		£	s.	d.		
May	13	22	10	0	dec.	3/9
,,	14	21	17	6	,,	12/6
,,	18	22	3	9	inc.	6/3
,,	19	22	18	9	,,	15/-

Lead (soft foreign, prompt)

		£	s.	d.		
May	13	23	12	6	inc.	2/6
,,	14	22	18	9	dec.	13/9
,,	18	22	12	6	,,	6/3
,,	19	23	11	3	inc.	18/9

Electrolytic Copper

		£	s.	d.		
May	13	64	0	0	inc.	10/-
,,	14	63	0	0	dec.	20/-
,,	18	64	0	0	inc.	20/-
,,	19	64	0	0	No change	

Tin (English ingots)

		£	s.	d.		
May	13	250	0	0	inc.	40/-
,,	14	249	5	0	dec.	15/-
,,	18	250	0	0	inc.	15/-
,,	19	254	10	0	,,	90/-

Spelter (Electro. 99.9 per cent.)

		£	s.	d.		
May	13	25	3	9	dec.	3/9
,,	14	24	11	3	,,	12/6
,,	18	24	17	6	inc.	6/3
,,	19	25	12	6	,,	15/-

Lead (English)

		£	s.	d.		
May	13	25	10	0	No change	
,,	14	25	0	0	dec.	10/-
,,	18	24	15	0	,,	5/-
,,	19	25	10	0	inc.	15/-

Imports and Exports of Pig-iron, Castings, etc., in April and the Four Months 1937, compared with April and the Four Months 1936.

	April.		Four months.		April.		Four months.	
	1936.	1937.	1936.	1937.	1936.	1937.	1936.	1937.
	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Imports.								
Pig-iron—from British India	4,442	9,645	22,475	54,187	13,645	33,347	70,132	182,602
,, ,, Other British Countries	—	—	—	5,070	—	—	—	21,167
,, ,, Foreign Countries	3,533	11,541	9,483	18,641	15,314	64,931	48,400	109,128
Total	7,975	21,186	31,958	77,898	28,959	98,278	118,532	312,897
Castings and forgings	793	192	2,993	944	25,754	7,591	97,079	27,948
Cast pipes and fittings	136	36	445	343	5,400	1,787	15,972	9,633
Stoves, grates, etc.	70	60	221	244	6,144	10,669	25,742	29,567
Baths	345	935	2,248	3,219	9,546	23,030	57,658	76,957
Hollow-ware, all kinds	295	387	1,089	1,183	19,085	22,138	62,763	70,531
Exports.								
Pig-iron, forge and foundry	3,921	10,752	16,715	37,069	14,867	53,819	61,991	176,064
,, acid	5,077	5,247	12,338	20,673	17,786	30,222	42,405	104,641
,, basic	55	3	105	394	361	22	545	2,420
Total	9,053	16,002	29,158	58,136	33,014	84,063	104,941	283,134
Castings and forgings	387	153	1,565	1,037	14,451	6,463	55,985	38,241
Cast pipes and fittings, up to 6 in. diameter	5,172	5,309	17,900	18,894	51,663	56,319	197,686	201,838
,, ,, over 6 in. ,,	3,188	4,383	14,964	12,675	25,359	33,928	120,663	99,647
Stoves, grates, etc.	735	1,043	3,455	4,006	37,718	52,174	174,281	211,608
Sanitary cisterns	272	316	1,022	1,217	7,960	11,139	32,215	39,299
Bedsteads, including tubes therefor	421	593	1,682	1,937	15,921	21,725	62,568	72,914
Cast hollow-ware	429	513	1,726	1,827	15,326	16,816	61,860	61,697

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EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

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MACHINERY—*Continued*

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